

*Group 3.* Strains resulting from selections made from Marquis at experiment stations. In this group are strains II, III, IV and XIII. Strains II and III represent two distinct types which compose Strain I, the former being unlike Marquis in several respects.

*Group 4.* Strains resulting from selections made from Marquis by individual farmers. This group consists of strains VI, XII and XIV.

Of the 15 strains only four, numbers IV, VI, XII and XIII, are known fairly definitely to be pure line selections from the original Marquis. Strains I, VI, XII, XIII and XIV are grown extensively in Saskatchewan.

#### NURSERY METHODS.

The nursery tests occupied a space 61 feet by 81 feet on summer fallow. The soil was a dark clay loam with a small proportion of sand. The piece was level and its uniformity may be judged by the coefficients for soil heterogeneity which were obtained by a method recently suggested by Hayes (7). The yield of each plot of each strain was expressed on a percentage basis, the average yield of the strain being taken as 100. Correlation coefficients were computed to express the degree of relationship for yielding ability of plots different distances apart. The coefficient for plots separated by one plot was  $.302 \pm .049$ ; for plots separated by 5 it was  $.276 \pm .051$ ; for plots separated by 10 it was  $.118 \pm .058$ . These coefficients are unusually low; consequently the probable error of a difference is not reduced much, even for strains averaging one plot apart throughout the test. The reduction in the probable error when  $r_{xy}$ , the correlation coefficient, is  $.302$  is 16.4% and when  $r_{xy}$  is  $.276$  is 15%\*.

The fifteen strains were systematically replicated fifteen times in single 18 foot rows (plots) one foot apart. The order in which the strains appeared within each section of five was varied mathematically so that no strain adjoined another more than 8 times in 16. This reduced the error due to competition between strains. Within each section of five the strains were an average distance apart of about one plot; consequently a 16.4% reduction in the probable error of a difference was applied. The sections of five strains each were as follows, Sec. 1: I, II, III, IV, VI; sec. 2: X, XI, XII, XIII, XIV; sec. 3: V, VII, VIII, IX, XV. Strains of section 1 were separated from strains of section 2 by five plots on the average and a 15.0% reduction in the probable error of a difference was used. Strains of sections 1 and 3 averaged ten plots apart and no reduction in probable error was allowable owing to the lack of significance of the coefficient ( $.118 \pm .058$ ).

\*The probable error of a difference between the yields of two strains is modified by the degree of relationship for yielding ability of the plots of the two strains, which is expressed by the correlation coefficient  $r_{xy}$ . The formula used for  $E_{x-y}$  is  $\sqrt{(E_x)^2 + (E_y)^2 - 2r_{xy} E_x E_y}$ . The effect of different values of  $r_{xy}$  on  $E_{x-y}$  is found by assuming that  $E_x = E_y = 1$ ; then  $E_{x-y} = \sqrt{2(1 - r_{xy})}$ . The substitution of different values of  $r_{xy}$  in the equation gives values of  $E_{x-y}$  from which the percentage reduction in  $E_{x-y}$  is computed. When  $r_{xy} = .0$ ,  $E_{x-y} = \sqrt{2} = 1.414$  and there is no reduction in  $E_{x-y}$  since there is no correlation. If  $r_{xy} = .302$  then  $E_{x-y} = 1.182$  and the percentage reduction in  $E_{x-y}$  is  $100 - \frac{E_{x-y}(100)}{\sqrt{2}} = 16.41$ .

During the season the date of heading, length and strength of straw, date of maturity and other notes were recorded. Previous to harvest 200 plants of each strain were taken at random from the sixteenth replicate for detailed laboratory study. The remaining 15 replicates were harvested for yield and milling and baking tests. Only the central 16 feet of each row were harvested, the foot at each end of a row being discarded to offset border effect.

A single season's results on physical characters, as, earliness of maturity, yield and milling and baking quality are usually not conclusive. On the other hand, morphological characters, such as glume length or beak shape, are subject to little seasonal variation. The present paper deals principally with morphological comparisons between different strains received under the name Marquis. The 1926 data on physical characters are of distinct value in connection with these comparisons and are therefore included here.

#### LABORATORY METHODS.

The 200 individually harvested plants of each strain were studied for spike and glume characters. The spike borne by the tallest culm was considered representative of a plant. Strain VI, a uniform strain of average desirable type, was chosen as the standard and ten spike and glume characters of each of 25 plants taken at random were studied statistically, all measurements being recorded. Following this, each strain, including Strain VI, was studied. First every spike was examined and the typical separated from the non-typical. Then a detailed written description of each strain was made. Finally, exact measurements of ten spike and glume characters were recorded for each non-typical spike and five typical spikes of each strain. The latter were measured simply for comparison with the non-typical spikes. Strains that were found to consist of more than one general type were separated into their component parts and each type studied separately as a sub-strain. In this case the off-types or non-typical plants were considered as off-types of the strain as a whole.

A special study of 80 glumes of Strain III was undertaken in order to determine the reliability of visual examination compared with rule measurement. The characters used were length and width of the secondary glume of the fourth fertile spikelet from the base of the spike. These characters were found to be as difficult to estimate visually as any of the other spike and glume characters studied. The correlation between the results obtained by visual estimation and those from rule measurement both taken to 0.1 mm., was  $0.72 \pm 0.04$  for glume length and  $0.69 \pm 0.04$  for glume width. These coefficients are high and warranted placing confidence in a visual classification of spikes. In the following description of methods of taking the data the terms used in visual estimation are omitted as they were the usual adjectives, large, small, medium, narrow, etc.

Density was taken as the length in millimeters of the most centrally located ten internodes of the spike.

Strains were classified as typical Marquis and non-Marquis according to their general character. Those that differed decidedly from Marquis in one or more easily observable characters were classed as non-Marquis. The

description of Marquis as given in 1922 by Clark, Martin and Ball (3) in their "Classification of American Wheat Varieties" is accepted here as representing typical Marquis except for spike density, Marquis being considered mid-dense rather than dense.

Spike shape was of two general kinds; fusiform, or tapering from the middle toward both base and apex, and cylindrical, which differs from fusiform in that the internodes toward the apex are shortened and the breadth of the spike at the tip is almost as large as at the middle. Marquis has a fusiform spike.

The glume (outer or empty glume) of typical Marquis is nearly twice as long as broad, has a square shoulder and a short acute beak. Both Vavilov (14) and Percival (9) emphasize the importance of glume characters for identification purposes. Percival states, "The form of the empty glume is one of the most constant characters of wheat and of the greatest value in distinguishing nearly related forms". The characteristic glume shape of Marquis is not found in the glumes near the extremities of the spike nor in the primary or lower glume of any spikelet but in the secondary or higher glumes of spikelets that are about a third of the distance up from the base of the spike. To determine the precise glume to employ when studying the glume characters of a spike, a special investigation was made, which is described in Part 2 of this paper. For the strain test, the secondary glume of the fourth fertile spikelet from the base of the spike was used.

The glumes were measured on a sheet of paper having horizontal and vertical lines 1 mm. apart. The measurements were made by means of a tripod lens with a magnification of 4 times. Readings were estimated to 0.1 mm. The width was taken at the broadest part of the glume, which is about midway between the base and apex, exclusive of the papery portions that occur on the margins. The length of the glume was taken from its base to the base of the beak. The term "beak" is used here for the short tooth which terminates the keel. The base of the beak is defined as the most abrupt part of the curve between the tip of the beak and the shoulder. The term "shoulder" refers to the more or less rounded portion of the glume between the beak and the lateral margin. Pye *et al* (10) consider glume dimensions too variable to make measurements advisable. The glume dimensions are found to be reasonably reliable if the secondary glume of the fourth fertile spikelet from the base of a normal spike is used.

Shoulder shape is described in one of four terms, the critical factor being the angle of the shoulder with the near side of the beak, viz: oblique, where the shoulder slopes off and downward from the beak rather abruptly; round, shoulder extending outward and downward from the beak in a gradual curve; square, the shoulder extending straight outward almost at right angles with the near side of the beak and then curving downward abruptly; elevated, shoulder extending outward and upward from the beak before curving downward.

A separate study was made to determine the best method of measuring shoulder width. Measuring across the glume at a distance of 0.5 mm. below the base of the beak was found to be satisfactory. The details of this special study appear in Part 2 of this paper. It was not found necessary to use the

lateral tooth of the shoulder in this study although for varietal descriptions it has been used by Scofield (12), Percival (9) and others.

The beak is described as acute or pointed and obtuse or blunt, the latter shape not being typical of Marquis. Beak length was measured from the base to the tip. The width was taken horizontally across at the base of the beak.

Spikes differing from the normal in one or more of the above mentioned spike and glume characters were considered non-typical.

Eight kernel characters were used. They were, grain shape, length, thickness, plumpness, color and texture, germ end shape and crease width.

### RESULTS.

At the time of seeding the nursery rod row plots, certain differences between Strains I, II and III were known, for Strains II and III were simply mass selections of the two distinct types of Strain I. As far as the other strains were concerned, no definite study of differences had been made previously. All of the strains excepting II, the non-Marquis type of Strain I, were supposed to be Marquis.

TABLE I—*Summary of nursery data and yields obtained from fifteen strains of Marquis wheat replicated fifteen times in rod row plots in 1926.*

Strain No.	Days from seeding to ripening		Height in inches	Strength of straw in %	Yield in bushels per acre	Diff. between Strain IV and others in bus. per acre	Diff. divided by its prob. error
	head-ing	head-ing					
I	65	108	35.0	93	41.20±0.94	2.27±1.08	2.10
II	66	109	35.0	96	45.74±1.04	6.81±1.14	5.97
III	65	108	34.8	95	42.19±0.96	3.26±1.09	2.99
IV	65	108	34.5	95	38.93±0.88		
V	65	108	36.0	93	43.16±0.98	4.23±1.31	3.23
VI	65	108	34.3	95	41.11±0.93	2.18±1.07	2.04
VII	65	108	34.3	93	39.50±0.90	0.57±1.26	0.45
VIII	69	109	36.5	93	39.13±0.89	0.20±1.25	0.16
IX	66	108	33.8	93	44.94±1.02	6.01±1.35	4.45
X	65	108	35.0	94	42.30±0.96	3.37±1.11	3.04
XI	65	108	33.5	95	39.07±0.89	0.14±1.15	0.12
XII	65	108	34.0	95	40.49±0.92	1.47±1.08	1.36
XIII	65	108	34.3	95	40.77±0.93	1.84±1.09	1.69
XIV	65	108	33.8	95	39.41±0.89	0.48±1.06	0.45
XV	65	108	33.3	94	39.07±0.89	0.14±1.25	0.11

\* Probable errors of yields were calculated by Hayes' deviation from mean method.

Table 1 summarizes the 1926 nursery data and yields of the fifteen strains. Small differences may be considered important for the number of replicates was large and the probable errors were low. The strains differed very little in earliness, but Strains II and VIII were slightly later than the others. Some height differences were apparent; Strains V and VIII were taller while IX and XIV seemed slightly shorter than the rest.

The yields varied considerably. Strains IV and II differed by 6.81 bushels per acre, which amounted to 5.97 times the probable error of the difference.

The odds against this difference being due to chance are 19,000 to 1. Three other strains, V, IX and X, excelled IV by amounts that exceeded three times the probable error of the difference. Strain III also seemed to out-yield Strain IV.

Observation during the growing period indicated that Strains I and X were identical, both containing two types, one not being Marquis. It also appeared that Strains V, VIII and IX were not Marquis. Strain V was found to consist of two distinct types both rather unlike Marquis. Strain VIII differed from Marquis in having a conspicuous bloom on the leaves and glumes. Strain IX was unlike Marquis in spike type.

Since some of the strains proved not to be Marquis and the nursery plots were single rod rows, the yields were studied in an effort to discover errors due to competition. Strain II yielded well above Strains I, III, IV and VI, the only ones nearby. These latter strains if robbed by Strain II, should have reflected the effect in their yields. In the first 14 replicates each of these strains was beside Strain II seven times. The average yields of plots of Strain I that were next to plots of Strain II was computed, and then the average for Strain I plots not adjacent to Strain II. Averages were computed similarly for Strains III, IV and VI. It was found that Strain I plots adjacent to Strain II yielded 5.2% higher than the plots not adjacent to Strain II. For Strains III, IV and VI the difference was in favor of plots not next to Strain II, the percentages being 5.2, 1.0 and 2.5, respectively. None of the differences is significant, the highest odds being 3.5 to 1.0 according to Student's method.

TABLE 2.—Comparison of the fifteen Marquis strains for grain characters from material grown at Saskatoon in 1926.

Strain No.	Grain shape	Grain length	Grain thickness	Germ end shape	Crease width	Plumpness %	Color score	Texture score
I	ovate	short	thick	blunt	wide	80	85	85
II	"	"	"	"	"	75	90	90
III	"	"	"	"	"	80	80	85
IV	"	"	"	"	"	80	85	85
V	oval	mid. l.	thin	"	narrow	90	85	85
VI	ovate	short	thick	"	wide	85	85	90
VII	"	"	"	"	"	85	90	90
VIII	"	"	thin	pointed	narrow	80	70	60
IX	"	"	thick	blunt	wide	70	80	80
X	"	"	"	"	"	80	85	85
XI	"	"	"	"	"	80	85	90
XII	"	"	"	"	"	80	85	85
XIII	"	"	"	"	"	80	85	85
XIV	"	"	"	"	"	80	85	85
XV	"	"	"	"	"	80	85	85

Abbreviations: mid. l.—mid-long.

Data on grain characters appear in Table 2. Most of the strains were very similar in the characters studied. They have short, thick, ovate, moderately plump, bright grains with blunt ends, wide creases and hard vitreous texture. Strains V and VIII had oval medium-thick grains with a medium-narrow crease. Strain V had also a longer grain than true Marquis. The grain of Strain VIII differed from all of the others, having a pointed germ end and poor color and texture. Strain IX was low in plumpness.

TABLE 3.—*The summarized results of milling and baking tests made by two laboratories\* on the fifteen strains of Marquis wheat grown in a replicated row test in 1926.*

Strain	Milling data		Baking data			
	crude protein (Nx5.7)	Flour %	Water absorption %	Loaf volume in cc.	Color score	Texture score
I	16.32	69.3	54.8	2200	93.0	98.5
II	16.43	71.1	55.8	2073	91.0	96.5
III	16.02	72.2	57.2	2230	97.0	98.5
IV	16.25	71.1	55.7	2210	94.5	97.5
V	16.35	71.4	56.5	2315	95.5	97.0
VI	16.08	69.8	55.9	2265	97.0	98.5
VII	16.54	72.7	55.6	2155	92.5	98.0
VIII	16.41	66.6	52.9	1965	90.0	90.0
IX	16.09	69.9	54.3	2210	92.0	95.5
X	16.26	71.3	54.4	2130	95.0	98.0
XI	16.40	73.4	55.6	2135	96.5	98.0
XII	16.41	70.2	55.0	2103	95.0	98.0
XIII	16.10	71.9	54.7	2178	97.5	97.5
XIV	16.32	70.8	55.4	2085	98.5	98.5
XV	16.31	70.7	55.7	2120	98.5	98.5

\*Milling and baking tests were made by Mr. Alan Robinson of the Chemistry Department, University of Saskatchewan, while holding a bursary from the National Research Council of Canada, and also by the Milton-Hersey Co., Winnipeg.

The results of the milling and baking tests are summarized in Table 3. In milling quality all the strains were high excepting IX which was only fair and VIII which was poor. In baking quality Strain V was high, excelling all others in loaf volume, II and VIII were poor, IX just fair, and the others high excepting possibly I and VII which were low in crumb color score.

TABLE 4. *Comparison of fifteen Marquis strains for certain spike and glume characters from material grown in Saskatoon in 1926.*

Strain No.	Marquis or not	Type		Density	Spike		Glume		Shoulder		Beak		
		Frequen- cy %	Uni-form- ity		Shape	No. basal sterile spikelets	Lng.	Width	Shp	Width	Shp	Lng	Width
I	not M	34	fg	dense	cyl	few	med	med-	sq	nar	ob	med	med
I	M	44	g	mid.d	fus	many	med	med	sq+	med	ac	med	med
II	not M		fg	dense	cyl	few	med	med-	sq	nar	ob	sh	med
III	M		g	mid.d	fus	many	med	med	sq+	nar	ac	med	med
IV	M		g	mid.d	fus	many	med	med	sq	med	ac	med	med
V	not M	27	fg	lax	fus	few	med+	med-	sq	nar	shr	lg	med
V	not M	64	fg	dense	fus	many	med	med+	sq-	nar	ac	med	med
VI	M		g	mid.d	fus	many	med	med	sq	med	ac	med	med
VII	M		g	mid.d	fus	many	med	med	sq	med	ac	med	med
VIII	not M		g	dense	cyl	many	med-	med	sq	med	ob	med	med
IX	not M		f	mid.d	fus	many	med-	med+	sq	med	ac	sh	med
X	not M	32	fg	dense	cyl	few	med	med-	ro+	nar	ob	sh	med
X	M	53	g	mid.d	fus	many	med	med	sq	med	ac	med	med
XI	M		fg	mid.d	fus	few	med	med	sq	med	ac	med	med
XII	M		g	mid.d	fus	many	med	med-	sq	nar	ac	med	med
XIII	M		g	mid.d	fus	few	med	med	sq	med	ac	med	med
XIV	M		vg	mid.d	fus	many	med+	med	sq	med	ac	med	med
XV	M		fg	mid.d	fus	few	med	med	sq	med	ac	med	med

Abbreviations: Lng, length; Shp, shape; not M, not Marquis; M, Marquis; f, fair; fg, fairly good; g, good; vg, very good; mid.d, mid-dense; fus., fusiform; cyl, cylindrical; med, medium; med-, slightly short or narrow; med+, slightly long or wide; ro+, rounded with tendency towards square; sq-, square but tending toward round; sq, square; sq+, square with tendency towards elevated; nar, narrow; ob, obtuse; ac, acute; shr, sharp or very acute; sh, short; lg, long.

In Table 4 the data on spike and glume characters are summarized. In this table the distinct types of Strains I, V and X are considered separately.

Strain II and the non-Marquis types of Strains I and X appear to be identical and differ from Marquis in having dense, cylindrical spikes with a few sterile spikelets at the base, somewhat narrow glumes, narrow shoulders and thick obtuse beaks. Strain VIII resembled these types in having a dense, cylindrical spike and a thick obtuse beak. Strain IX and the two non-Marquis types of Strain V differed from Marquis and from one another in several characters.

The typical Marquis strains were very similar in most respects. Strains III, VI, VII and the typical Marquis types of Strains I and X are quite similar. Strain XII has narrower glumes and shoulders than VI. Strains XI, XIII and XV differed from VI in having few fertile spikelets at the base of the spike instead of many. Strain XIV seemed to be the most uniform of all and had broader glumes than VI.

Representative glumes of the different strains are pictured in Figure 1.

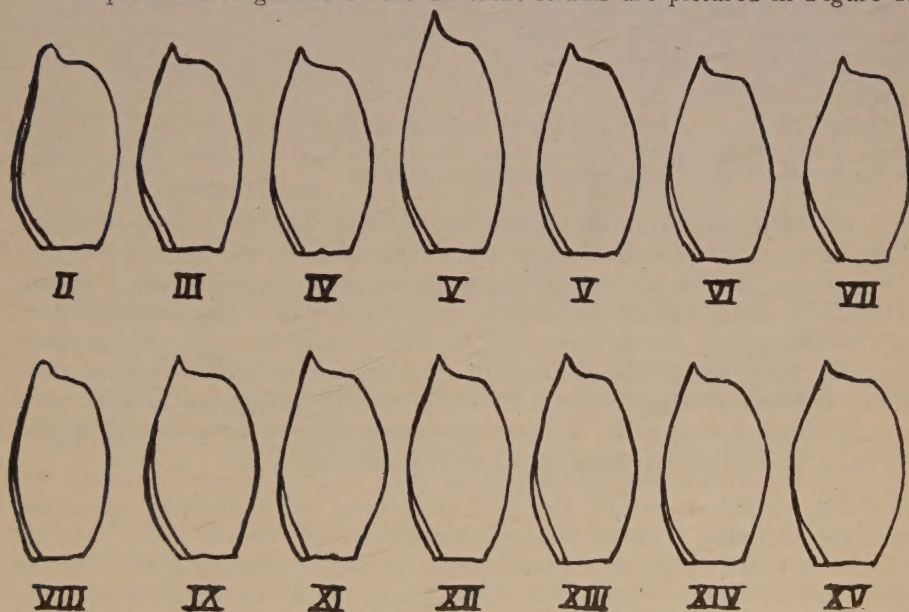


FIGURE 1. The shape of the secondary glume of the fourth fertile spikelet from the base of the spike for each of the Marquis strains studied.

Table 5 shows the percentage frequency and nature of the non-typical plants that were found in the different strains. In the case of strains consisting of two different types the Marquis type, or the one most like Marquis, was considered to be normal and plants of the other type were classed as non-typical. Among the different kinds of non-typical plants found, the type with dense spikes and short blunt beaks, represented by Strain II, was the most important owing to its prominence in Strain I. It was found that Strains VII and X also had a considerable proportion of this dense type of non-typical plant. Strain XI showed 4% of an off-type similar to one of the types of Strain V differing from the Strain II type in the width of the glume.

Strains I and X appeared to be almost identical with respect to non-typical plants. The non-typical plants which were classified as intermediates probably resulted from natural crossing between the two main types, since various degrees of intermediacy between these types were observed.

TABLE 5.—*The percentage frequency and the nature of the non-typical plants found in the two hundred plant sample of each Marquis strain grown in 1926 at Saskatoon.*

Strain No.	NON-TYPICAL PLANTS			PERCENTAGE OF NON-TYPICAL PLANTS			
	Total number	Total %	With dense spikes and short blunt beaks	Intermediate between the dense off-type and true Marquis	With dense spikes, short broad glumes and obtuse beaks	Only slightly off-type	Not included in the preceding classes
I	112	56.0	34.0	20.5		0.5	2.0
II	4	2.0					2.0
III	3	1.5	1.0				0.5
IV	5	2.5				1.5	1.0
V	62	31.0			23.5		7.5
VI	8	4.0	1.0			1.5	1.5
VII	18*	9.0	8.0				1.0
VIII	6	3.0	2.5				0.5
IX	2	1.0				1.0	
X	95	47.5	32.5	15.0			
XI	11	5.5			4.0	0.5	1.0
XII	3	1.5				1.5	
XIII	9	4.5				3.0	1.5
XIV	1	0.5	0.5				
XV	4	2.0				0.5	1.5

\* Not including 20 plants of the Preston and Huron varieties.

Of the typical Marquis strains number XIV had the fewest off-types. This strain resulted from a single plant selected from the original Marquis by a farmer who took particular pride in the purity of his wheat. Strains IV and VI, both of which originated as pure Marquis were also low in percentage of non-typical plants. Strains XIV and VI have been grown principally in fairly large fields with consequently the bulk of the plants isolated from other varieties of wheat. Strain IV until recently was grown in small plots near plots of other varieties, but careful rogueing has tended to keep down the number of off-types resulting from natural crossing.

The combined data of Tables 1 to 5 reveal rather definite similarities and dissimilarities between strains. Strains I to X appear to be identical. They were closely alike in grain characters, milling and baking qualities and in the characters of the types comprising them. In yield they were not shown to be different. Strains XI and XIII resembled each other strongly in most characters but were unlike in off-types. Strain V consists of two types neither of which is Marquis. Strains VIII and IX are clearly not Marquis. In addition to the qualities brought out in the tables, Strain VIII is unlike Marquis in having bluish green foliage, and at maturity purplish straw and light brown glumes. Strains III, IV, VI, VII, XI, XII, XIII, XIV and XV, while they showed some differences in various characters, appear to be typical Marquis.

The histories of the different strains were obtained as fully as possible after all the data had been taken (see Appendix). It was found that Strain X was grown from bulk seed of Strain I.

In Table 6 a few representative non-typical or off-type plants are compared with typical plants of the strains in which they are found. The non-typical plants varied from those which were only slightly off-type to those which were decidedly non-typical in several respects.

TABLE 6.—*Comparison of typical and a few non-typical plants of some typical Marquis strains for various spike and glume characters from material grown in the nursery in 1926.*

Strain No.	Description of Material	Spike		Glume		Shoulder		Beak	
		D.	sh	l	w	sh	w	sh	w
VI	Mean of 5 typ. pls. from random 200 pls.	52	f	6.7	3.7	s	2.3	a	.7—
"	*Max. " " " "	53	f	6.9	3.9	s	2.4	a	.8
"	Min. " " " "	51	f	6.4	3.6	s	2.2	a	.5
"	Very non-typ. pl. " "	41†	f	6.8	3.2	s	2.0	ob	.5
"	Slt. " " " "	49	f	6.5	3.5	s	2.0	a	.8
IV	Mean of 5 typ. pls. from random 200 pls.	52	f	6.8	3.8	s	2.2	a	.6
"	Max. " " " "	53	f	7.0	4.1	s+	2.5	a	.7
"	Min. " " " "	51	f	6.6	3.7	s	2.2	a	.5
"	A non-typ. pl. " "	43	f	6.7	3.2	o	1.4	a+	.3
XII	Mean of 5 typ. pls. from random 200 pls.	52	f	6.8	3.5	s	2.0	a	.6
"	Max. " " " "	55	f	7.0	3.8	s+	2.2	a	.7
"	Min. " " " "	48	f	6.5	3.3	s	1.8	a	.6
"	Slt. non-typ. pl. " "	52	f	6.7	3.2	r	2.0	a	.7
XIII	Mean. of 5 typ. pls. from random 200 pls.	54	f	7.0	3.6	s	2.2	a	.6+
"	Max. " " " "	56	f	7.2	3.8	s	2.3	a	.7
"	Min. " " " "	52	f	6.6	3.5	s	2.1	a	.5
"	A non-typ. pl. " "	49	f	7.4	3.1	r	1.6	a	.6
"	" " " " "	45	f	7.1	3.4	s	1.8	ob	.3
"	" " " " "	63	f	7.0	4.0	s	2.6	a+	.9
XIV	Mean of 5 typ. pls. from random 200 pls.	51	f	6.7	3.8	s	2.3	a	.6
"	Max. " " " "	53	f	6.9	4.0	s	2.5	a	.7
"	Min. " " " "	50	f	6.5	3.7	r	2.2	a	.5
"	A. non-typ. pl. " "	45	f	6.7	3.5	s	2.2	ob	.4

\* The maximum or largest and minimum or smallest measurements, respectively, that were obtained from the five plants measured.

† Non-typical character measurements are underscored.

Abbreviations: D, density; sh., shape; l., length; w., width; typ., typical; pls., plants; slt., slightly; f., fusiform; r., rounded; s., square; o., oblique; a., acute; a+, slightly blunted; ob-, fairly blunt; ob., obtuse or blunt; s+, square with tendency toward elevated.

All plants classified as off-types do not prove to be non-typical when given a progeny test. Fluctuations due to environmental influence may have the same appearance as variations which are inherited. This is true of most inherited characters and warrants considering plants which appear to be only slightly non-typical in one or two characters as being probably typical genetically. But plants of normal growth that are extreme in two or more characters are likely to be genetically typical. Progeny tests were made in 1926 on a large number of Marquis plant selections and the original classification held good in over 99% of the cases where the character differences in the 1925 parental material were pronounced. A further discussion of these tests and the tabulated data are given in Part 2 of this paper.

#### DISCUSSION.

On the whole the typical Marquis strains were high in purity and true-ness to type and similar in yield, milling quality, baking quality and other economic characters. Yet they appeared to differ in many small points. It is obvious that a rather exhaustive test is required to establish with certainty that two fairly similar strains are identical, or conversely that two such strains are not the same.

Certain strains proved to be distinctly unlike Marquis. Of these, Strains V, VIII and IX do not answer the descriptions of any "forms" described by Percival (9) or varieties described by Clark, Martin and Ball (3); neither do Strain II and the dense types of Strains I and X, all of which appear to be identical.

Strain I has been shown to contain 34% of a dense-headed type quite unlike Marquis. As this strain is one of the most widely grown in Saskatchewan the presence in it of so large a proportion of a distinct non-Marquis type, fairly uniform in itself, is of particular interest. Considering only the strains that proved to be Marquis or largely Marquis, none had over one per cent of off-types with dense spikes, obtuse beaks and oblique shoulders excepting Strains I, VII, X and XI which had 34%, 8%, 32% and 4%, respectively. The dense off-type in Strain XI, however, differed from the off-type in Strains I, VII and X in having short broad glumes. Since Strains I and X proved to be the same the latter need not be considered further. It appears that Strain I came from the Indian Head Experimental Farm, Strain VII from the Brandon, Indian Head or Ottawa Farm and Strain XI from the Brandon Experimental Farm. As far as is known all of these strains were unselected with respect to uniformity of spike type. On the other hand in Strains IV, VI, XII, XIII and XIV, all selections from the original Marquis, only three plants of the 1000 examined approached the dense type of Strain I. Two of these were in Strain VI and one in XIV.

It is possible that Strain VII, minus the admixtures of other varieties which it contains, was fairly representative in 1911 of the original Marquis that came from Ottawa. Since it has been shown that Strain II, which represents this dense type, yields better than typical Marquis, it is reasonable to believe that the proportion of the off-type gradually increased from a very small amount to its present quantity. Assuming that there was 1.4% of this dense off-type in the original Marquis which was sent from Ottawa in 1907 and that it yielded ten per cent higher than the true Marquis, the proportion of the dense off-type could have increased as follows:

Year	Proportion of the dense off- type in %	Proportion of typical Marquis in %	Year	Proportion of the dense off- type in %	Proportion of typical Marquis in %
1907	1.4	98.6	1917	3.7	96.3
1908	1.5	98.5	1918	4.1	95.9
1909	1.7	98.3	1919	4.5	95.5
1910	1.9	98.1	1920	4.9	95.1
1911	2.1	97.9	1921	5.4	94.6
1912	2.3	97.7	1922	5.9	94.1
1913	2.5	97.5	1923	6.5	93.5
1914	2.8	97.2	1924	7.2	92.8
1915	3.1	96.9	1925	7.9	92.1
1916	3.4	96.6	1926	8.7	91.3

That is, in 1926 Strain VII could have 8.7% of the dense off-type. The presence of 4% of a somewhat similar off-type in Strain XI could be explained likewise.

If this hypothesis is correct why has not Strain I only about eight per cent of the dense type, instead of 34%? As a tentative explanation it may be supposed that during the period 1911 to 1920 rough mass selection was

occasionally practiced to free Strain I from plants with beards or brown chaff, for it is well known that these impurities appear in Marquis. The simplest way to eliminate these objectionable plants effectively would be to gather a sackful of desirable looking heads from a plot of the variety and use the seed of the selected spikes for the next year's test. Now it happens that the dense type of Strain I has a more attractive appearing spike than typical Marquis. People, when asked to choose a number of the best looking spikes from Strain I invariably select a preponderance of the dense type. A person going out to get a sackful of typical spikes of Strain I, and not wanting to discriminate with respect to variations in the general type of the variety, would probably unconsciously have taken the dense type far more frequently, relative to its proportion in the plot, than he would have taken the true Marquis. He would try to avoid only a noticeable admixture such as other known varieties and bearded, brown-chaffed and velvet-chaffed heads. If this process was repeated several times it is conceivable that the proportion of the dense type, instead of being 8 per cent in 1926 as in Strain VII, might be over 30 per cent.

## 2. GENETIC ANALYSIS OF MARQUIS STRAIN I.

Strain I is one of the most widely grown Marquis strains in Saskatchewan. It has for years been consistently high in yield and fairly high in milling and baking quality. The 1926 results show it to be slightly low in flour yield and loaf color score but in other commercial respects about the same as Strains VI, XII, XIII and XIV, which are also extensively grown in Saskatchewan. (See Tables 1 to 3.) It will be remembered that Strain I, unlike these other strains, is not uniform morphologically and consists of two distinct types, one characterized by a dense cylindrical spike with glumes quite different from Marquis (See Fig. 2 and Fig. 4-1), the other, typical Marquis. (See Fig. 3 and Fig. 4-2). See Table 4. During the season of 1925 it was thought advisable to study the types in Strain I.

## MATERIALS AND METHODS

In August 1925, 1220 single plants of Strain I were harvested at random from an area of about 200 square feet in a particularly even part of a seed increase field. The plants were numbered consecutively from 1 to 1220 and sorted during the winter into three lots, viz: Type II, those with dense spikes, obtuse beaks and other non-Marquis characters; Type III, those that appeared to be typical Marquis; Type A, plants that seemed more or less intermediate in character between types II and III. In addition to the intermediates there were some plants that resembled neither Type II nor Type III; these were added to the Type A lot. There were 279 plants of Type II, 809 of Type III and 132 of Type A. One spike of each selection was reserved unthreshed for reference and for later comparison with the progeny of that plant. Two or three spikes of each were threshed to furnish seed for the nursery. The remaining spikes of each plant, to the number of two or three, were bulked with similar surplus spikes from other plants of the same type, thereby furnishing seed of each type for a row yield test. The massed Type II material was called Strain II and the Type III material called Strain III.



Fig. 2

FIGURE 2. View of a typical progeny of Type II showing the strong erect attitude of the spikes.



Fig. 3

FIGURE 3. View of a typical progeny of Type III showing the inclined nodding attitude of the spikes.

These strains have been discussed in Part 1. The massed Type A material was discarded.

In the spring of 1926 the 1220 selections were sown on summer fallow by hand in separate five foot rows, using 25 seeds per row. The selections of each type were grouped together. Before harvest, a careful examination of several plants in each row was made. Notes were taken on type, uniformity and height. All rows were searched for off-type plants. One hundred and twenty progenies were selected for further test. From each of 25 progenies taken at random the first 10 plants in the row were harvested individually for laboratory study. The laboratory technic has been described in Part 1 of this paper.

Three Type III progenies taken from the 25 used for laboratory study were chosen for a special investigation of glume characters. Ten plants of each progeny were used and the whole group of 30 considered to be homogeneous. The object of this investigation was to ascertain the correct glume to use in taking measurements for the purpose of describing glume characters



FIGURE 4. Front and edge views of the two distinct types composing Strain I: 1—Type II; 2—Type III. Observe the greater density of the spike of Type II, especially toward the apex. The contrast between the blunt beak of Type II and the acute beak of Type III is shown clearly. This photograph also shows the differences between secondary and primary glumes: a—secondary glumes; b—primary glumes.

of Marquis. A similar investigation of glume character was made using 30 average plants of Ceres, Sask. 1212, a hybrid *vulgare* variety recently produced by Waldron (15) of the North Dakota Experiment Station from the cross, Marquis x Kota. Marquis and Ceres were chosen as they were fairly representative morphologically of the wheat varieties commonly grown in Western Canada.

### RESULTS

Examination of the 1,220 separate progenies grown in 1926 showed that with few exceptions the mother plants classified as Type II gave progenies of Type II and the plants classed as Type III gave Type III progenies. Some of the progenies from mother plants which had been considered Type II or Type III proved to be somewhat non-typical of the supposed parent type. Certain of these progenies were uniform and differed from Type II or Type III, respectively, in density of spike, shape of glume or beak characters.

Others lacked uniformity and appeared to be segregating for various spike and glume characters. Some were uniform excepting for one or two plants which had some resemblance to the other type and might have resulted from natural crossing between the two types. No progeny whose mother plants were classified as Type II proved to be Type III nor did any progenies from plants placed with Type III prove to be Type II.

Some of the progenies from mother plants that had been considered more or less intermediate and therefore classified as Type A proved to be Type II and others to be Type III. The reserve parent spikes in these cases were only slightly different from Types II and III, respectively. Many Type A progenies were unquestionably intermediate in character and others approached Type II or Type III rather closely. These progenies of variously intermediate character appear to be what would be expected theoretically from natural crossing between Types II and III.

Natural crossing in wheat occurs fairly readily in dry climates. In 1922, a fairly dry year at Saskatoon, a considerable amount of natural crossing must have taken place, for in 1923 no less than 50 natural crosses were found in the nursery plots\*. In 1923, a wet year at Saskatoon, and in 1925, which was wet until the middle of July, at which time flowering in wheat is usually ended, little natural crossing occurred. However, in 1924, a very dry year, natural crossing again was frequent. In view of these facts and the published reports of a number of investigators on the frequency of natural crossing in wheat it is reasonable to consider natural crossing as the major cause of the Type A or intermediate plants found in Marquis Strain I.

Ten plants each of 25 progeny lines taken at random were studied for several spike and glume characters. Eighteen of the lines were typical Marquis and seven were of the dense type with obtuse beaks. The plants of each line resembled the parental plant closely, with a few minor exceptions. To learn more about these exceptions, exact measurements of eleven spike and glume characters were made on five or six plants of each of eleven lines. Three of the 59 plants measured proved to be slightly non-typical. One had a very narrow oblique shoulder, another an oblique shoulder and slightly obtuse beak, and the third a beak nearly a half millimeter longer than the average.

In Table 7 one representative parental plant of Type III and one of Type II are compared with five average plants of their respective progenies with respect to eleven spike and glume characters. The purpose of this table is to illustrate the strong resemblance between parents and progeny that was noticeable throughout the material studied. In taking the data on the progeny plants the spikes that were most like the parental spike in size were chosen for measurement. This was done because it was observed that relatively large differences in spike density and in glume characters existed among the fully mature spikes of a single plant. The largest spike of each plant proved less accurate for use in comparing one plant with another than a well developed spike of approximately the average size for the strain. To insure accuracy in the comparisons, progeny spikes differing from the parental spike by more than 10 per cent in length were not used excepting in a few cases where spikes of the average size were not available.

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\*Unpublished results of the Field Husbandry Department, University of Saskatchewan.

TABLE 7.—Comparison of parent and progeny of one representative Type II line (No. 883) with one representative Type III line (No. 567) for eleven spike and glume characters.

Characters	Representative progeny plants grown in 1926					Parental plant grown in 1925	
	1	2	3	4	5	Mean	
Spike density	46	46	47	42	48	46	44
“ shape	cyl	cyl	cyl	cyl	cyl	cyl	cyl
“ type	II	II	II	II	II	II	II
Glume length	7.2	7.5	7.7	7.2	7.5	7.4	7.2
“ width	3.6	3.8	4.1	3.7	4.0	3.8	3.7
Shoulder shape	ro-	obl	obl	ro	ro-	ro-	obl
“ width	1.8	2.0	1.8	2.1	2.2	2.0	1.9
Beak shape	ob	ob+	ob+	ob+	ob+	ob+	ob+
“ length	0.7	0.8	0.5	0.5	0.7	0.6+	0.9
“ width	0.9	1.1	0.6	0.6	0.8	0.8	1.0
No. infertile spikelets at base	0.0	0.0	0.0	1.0	0.0	0.2	0.0
Spike density	54	49	52	53	48	51	51
“ shape	fus	fus	fus	fus	fus	fus	fus
“ type	III	III	III	III	III	III	III
Glume length	7.0	6.5	6.8	7.0	6.7	6.8	7.0
“ width	3.9	3.8	3.7	3.7	3.8	3.8	4.0
Shoulder shape	sq	sq	ro	ro	sq	sq-	sq
“ width	2.0	2.2	1.9	1.8	2.0	2.0	2.1
Beak shape	ac	ac	ac	ac	ac	ac	ac
“ length	0.8	0.6	0.7	0.6	0.6	0.7-	0.6
“ width	0.7	0.6	0.7	0.5	0.6	0.6	0.6
No. infertile spikelets at base	2.0	3.0	3.0	2.0	3.0	2.6	2.0

Abbreviations: cyl, cylindrical; fus, fusiform; II, non-Marquis; III, Marquis; obl, oblique; ro-, slightly rounded, almost oblique; ro, rounded; sq-, not clearly square, somewhat rounded; sq, square; ac, acute; ob-, obtuse; ob+, very blunt.

The data were sufficiently extensive to show the close similarity between the parents grown in 1925 and the progeny raised in 1926. The dense, cylindrical spike with rounded to oblique shoulder, blunt relatively short broad beak and few if any infertile spikelets at the base, which is characteristic of Type II, was unmistakable in every Type II progeny plant examined. Similarly the Type III plants were true to type with the minor exceptions previously mentioned.

In Table 2 Strain II is shown to have better color, but to be less plump than Strain III. Further data were secured on those characters from the 180 Marquis lines selected from the nursery as the best of the 1220 sown. Notes on seed plumpness and color were taken on a percentage basis. Sixty-one of the selected lines were of Type II (the Strain II type) and 117 of them of Type III (the Strain III type). The distribution of the lines on the basis of their percentage color value is given in Table 8

TABLE 8. Distribution of 180 lines of Strain I according to the percentage color value of the grain.

Type	Percentage color value								No. of lines
	55	60	65	70	75	80	85	90	
II				3	5	7	15	19	61
III	1	11	15	39	29	15	6	1	117

Mean % for Type II  $86.39 \pm 0.60$

Mean % for Type III  $71.75 \pm 0.42$

Difference  $14.64 \pm 0.73$



FIGURE 5. Twenty average grains from each of two representative lines of Strain I: 1—a line of Type III, plump but not uniformly bright in color; 2—a line of Type II, slightly shrunken but having fairly good color.

There was a highly significant difference between the two types with respect to seed color. The mean for Type II was  $86.4 \pm .6\%$  and for Type III  $71.8 \pm .4\%$ , giving a difference of  $14.6 \pm .7\%$  in favor of Type II. It will be remembered that Strain II was one of the poorest strains for baking quality, particularly with respect to loaf color, and that Strain III was high in baking quality.

TABLE 9. Distribution of 180 lines of Strain I according to their percentage plumpness of the grain.

Type	Percentage plumpness									No. of lines
	55	60	65	70	75	80	85	90	95	
II	1	10	22	16	8	4				61
III			2	10	19	27	42	16	1	117
Mean % for Type III $81.37 \pm 0.39$										
Mean % for Type II $67.62 \pm 0.50$										
Difference $13.75 \pm 0.63$										

The distribution of the 180 lines of Strain I for percentage plumpness of the grain is given in Table 9. The mean for Type III was  $81.4 \pm .4$  and for Type II  $67.6 \pm .5$ , giving the highly significant difference of  $13.7 \pm .6$  in favor of Type III. (See Fig. 5.)

#### DETERMINATION OF THE GLUME TO USE FOR GLUME CHARACTER MEASUREMENTS.

A special study was made to determine the glume to use in measuring the glume character of a plant. In describing different varieties or the segregates from crosses between different varieties especially refined methods of taking glume measurements are usually not necessary. Clark, Martin and Ball (3) mention that, "Considerable variation exists in shoulder width and shape in different varieties and also in different spikes of the same variety and even among the glumes on a single spike." They emphasize the classification value of these characters but they do not refer to the glumes of any particular part of a spike or of a spikelet as being best for measurement. Scofield

(12) and Pye *et al.* (10) also do not mention taking glumes from any particular part of the spike. Percival (9) and Vavilov (14) use glumes from spikelets at the middle of the spike but do not distinguish between the primary and secondary glumes. Denaiffe *et al.* (5) made a careful study of glume characters in 75 varieties of wheat. They draw attention to the pronounced difference between the primary and secondary glume, and, in describing the glume character of a variety, use the secondary on account of its more vigorous development. They give preference to glumes slightly below the middle of the spike.

In the present study it was found imperative to determine as exactly as possible which glume to use. It was obvious at the beginning that to use primary and secondary glumes promiscuously, and to take glumes from near the top of one spike and near the base of another would be highly inaccurate. Glumes from different parts of the same spike often differ more than glumes from the same part of spikes from distinct varieties. There are also large differences in shoulder width and shape between the primary and secondary glumes.

It has been the practice of the writer for several years to use the secondary glume of the fourth fertile spikelet from the base of the largest spike for determining the glume character of a plant. Measurements were taken on this glume, together with the primary glume of the same spikelet, and the secondary glumes of the fourth, seventh, eighth fertile and twelfth spikelets from the base of the spike. In addition, the secondary glume of a spikelet approximately one-third the distance from the base to the apex of the spike was used. The secondary glume of the fourth spikelet from the base of the spike is generally in the lowest fifth of the spike. The secondaries of the eighth fertile spikelet and of the twelfth spikelet from the bottom are usually in the upper two-fifths of the spike.

Ten plants were taken at random from each of three typical Marquis lines of Strain I. The largest spike of each of these 30 plants was used for taking the data. Similarly 30 plants of Ceres were used. Ceres was chosen because it differed markedly from Marquis in several spike and glume characters.

In Tables 10, 11 and 12, the measurements of seven different glumes from each of 30 spikes of Strain I are summarized. The coefficient of variability is used as the basis for comparison, taking the measurements of the secondary glume of the fourth fertile spikelet from the bottom as the standard. Table 10 shows the results obtained for measurements of glume length and width.

The secondary glume of the fourth fertile spikelet from the base of a spike appeared to be significantly less variable than the "secondary of the fourth," § both for glume length and width, and also less variable than the "primary of the fourth fertile" for glume width. No other important differences were found.

§"Secondary of the fourth" means "secondary glume of the fourth spikelet from the base of the spike." Needless repetition of all the words of this and similar expressions is avoided where the meaning is obvious.

TABLE 10.—Comparison of the measurements of different glumes on the largest spikes of 30 Marquis plants\* grown in 1926 using the characters, glume length and glume width.

Row of Table	Character	Glume used	Mean in mm.	Range in mm.	Standard deviation	Coefficient of variability	Diff. in coefficients of variability between rows	Diff. P.E. <sub>D</sub>	No. of glumes m's'd
1	Glume l. Prim., 4th fer.		6.94	6.5 to 7.8	.284	4.09±0.36	2 and 1=1.16±0.44	2.64	30
2	" " Sec., 4th fer.		6.86	6.5 " 7.2	.201	2.93±0.26			30
3	" " " 4th		6.44	5.8 " 7.1	.318	4.94±0.43	2 and 3=2.01±0.50	4.02	30
4	" " " 7th		7.14	6.6 " 7.6	.270	3.78±0.33	2 " 4=0.85±0.42	2.04	30
5	" " " 13rd		7.02	6.5 " 7.6	.281	4.00±0.35	2 " 5=1.07±0.43	2.48	30
6	" " " 8th fer.		7.18	6.7 " 7.6	.263	3.66±0.34	2 " 6=0.73±0.42	1.72	27
7	" " " 12th		6.97	6.5 " 7.8	.295	4.23±0.39	2 " 7=1.30±0.47	2.80	27
8	Glume w. Prim., 4th fer.		3.78	3.2 to 4.2	.280	7.40±0.65	9 and 8=2.56±0.77	3.32	30
9	" " Sec., 4th fer.		3.91	3.5 " 4.3	.189	4.84±0.42			30
10	" " " 4th		3.48	2.6 " 4.2	.399	11.45±1.00	9 " 10=6.61±1.08	6.12	30
11	" " " 7th		4.01	3.5 " 4.3	.236	5.89±0.51	9 " 11=1.05±0.66	1.58	30
12	" " " 13rd		3.96	3.5 " 4.3	.230	5.82±0.51	9 " 12=0.98±0.66	1.48	30
13	" " " 8th fer.		3.96	3.4 " 4.5	.254	6.42±0.59	9 " 13=1.58±0.72	2.19	27
14	" " " 12th		3.78	3.4 " 4.4	.253	6.69±0.61	9 " 14=1.85±0.74	2.50	27

\* Ten plants from each of three typical Type III progenies, lines 563, 564 and 565.

TABLE 11.—Comparison of the measurements of different glumes on the largest spikes of Marquis plants grown in 1926, using the character shoulder width.

Row of Table	Character	Glume measured	Mean in mm.	Range in mm.	Standard deviation	Coefficient of variability	Diff. in coefficients of variability between rows	Diff. P.E. <sub>D</sub>	No. of glumes m's'd
15	Shoul. w. Prim., 4th fer.		1.75	1.2 to 2.3	.217	12.40±1.08	16 & 15=4.28±1.29	3.32	30
16	" " Sec., 4th fer		2.34	1.9 " 2.7	.190	8.12±0.71			30
17	" " " 4th		2.22	1.8 " 2.8	.235	10.59±0.92	" 17=2.47±1.16	2.13	30
18	" " " 7th		2.11	1.8 " 2.5	.191	9.05±0.79	" 18=0.93±1.06	0.88	30
19	" " " 13rd		2.25	1.9 " 2.5	.167	7.42±0.65	" 19=0.70±0.96	0.73	30
20	" " " 8th fer.		2.10	1.8 " 2.4	.163	7.76±0.71	" 20=0.36±1.00	0.36	27
21	" " " 12th		2.06	1.6 " 2.4	.174	8.45±0.78	" 21=0.33±1.05	0.31	27
22	Shoul. w. Prim., 4th fer.		1.24	0.8 to 1.6	.175	14.11±1.23	23 & 22=2.68±1.58	1.69	30
23	" " Sec., 4th fer		1.68	1.2 " 2.2	.192	11.43±0.99			30
24	" " " 4th		1.66	1.1 " 2.0	.173	10.42±0.91	" 24=1.01±1.35	0.75	30
25	" " " 8th fer.		1.50	1.3 " 1.8	.135	9.00±0.83	" 25=2.43±1.29	1.88	27
26	" " " 12th		1.56	1.1 " 1.8	.169	10.83±0.99	" 26=0.60±1.40	0.43	27

\* Shoulder width taken 0.5 mm. below the base of the beak (low width).

† Shoulder width taken from the tip of the main nerve of the shoulder to the keel (high width).

TABLE 12.—Comparison of the measurements of different glumes on the largest spikes of Marquis plants grown in 1926 using the characters beak length and beak width.

Row of Table	Character	Glume measured	Mean in mm.	Range in mm.	Standard deviation	Coefficient of variability	Diff. in coefficients of variability between rows	Diff. P.E. <sub>D</sub>	No. of glumes m's'd
27	Beak l. Prim., 4th fer.		0.74	0.5 to 1.0	.136	18.38±1.60	28 & 27=3.77±2.05	1.84	30
28	" " Sec., 4th fer.		0.76	0.6 " 1.0	.111	14.61±1.27			30
29	" " " 4th		0.75	0.6 " 1.0	.102	13.61±1.19	" 29=1.00±1.74	.57	30
30	" " " 7th		0.72	0.5 " 0.9	.090	12.50±1.11	" 30=2.11±1.69	1.25	30
31	" " " 13rd		0.72	0.5 " 0.9	.081	11.25±0.98	" 31=3.36±1.61	2.09	30
32	" " " 8th fer.		0.59	0.4 " 0.8	.121	20.51±1.88	" 32=5.90±2.27	2.60	27
33	" " " 12th		0.50	0.4 " 0.6	.054	10.80±0.99	" 33=3.80±1.61	2.36	27
34	Beak w. Prim., 4th fer.		0.63	0.4 to 0.9	.112	17.77±1.55	35 & 34=0.69±2.23	0.31	30
35	" " Sec., 4th fer.		0.65	0.5 " 1.0	.120	18.46±1.61			30
36	" " " 4th		0.66	0.4 " 1.0	.122	18.48±1.61	" 36=0.02±2.28	0.09	30
37	" " " 7th		0.61	0.5 " 0.8	.076	12.46±1.10	" 37=6.00±1.95	3.08	30
38	" " " 13rd		0.63	0.5 " 0.9	.086	13.65±1.19	" 38=4.81±2.00	2.41	30
39	" " " 8th fer.		0.53	0.4 " 0.7	.096	18.11±1.66	" 39=0.35±2.31	0.15	27
40	" " " 12th		0.43	0.4 " 0.6	.055	12.67±1.16	" 40=5.79±1.98	2.92	27

Abbreviations: Diff./P.E.<sub>D</sub>, probable error of the difference in coefficients of variability divided by the difference; l, length; w., width; prim., primary; sec., secondary; 4th fer., 12 fer., the fourth and twelfth fertile spikelets, respectively, counting from the base of the spike; 4th, 7th, 12th, the fourth, seventh and twelfth spikelets, respectively, counting from the base of the spike; 1-3rd, a spikelet approximately one-third of the way up from the base of the spike.

Table 11 gives the results on shoulder width. As stated in the early part of this paper, measurements of shoulder width were made at two places to determine the most accurate method to use. These were 0.5 mm. below the base of the beak, and from the tip of the main shoulder nerve to the keel, which will be referred to as the "low width" and "high width", respectively. Both shoulder measurements were made on five different glumes of each spike.

The data in Table 11 indicate that the "low width" measurements were less variable than the "high width" measurements. The coefficients of variability of the five glumes ("primary of the fourth fertile" and the "secondaries of the fourth fertile, the fourth, the eighth fertile and the twelfth") upon which both measurements were made, may be compared by Student's method. The odds were 45:1 that the "low width" measurements are less variable than the others. Measurement of shoulder width a half millimeter below the base of the beak appears therefore to be the preferable method to use. As a matter of fact, this place of measurement is essentially that which is used most naturally when one is observing shoulder shape in the field.

Considering only the "low width" data it is seen from the table that the "primary of the fourth fertile" is more variable for shoulder width than any of the other glumes excepting the "secondary of the fourth".

Table 12 shows the data on beak length and beak width. Owing to the small size of the beak and the impossibility of determining exactly the location of its base, the length and width measurements made in this study are highly variable. Consequently they are not of much assistance in determining which glumes to use for measurement.

In addition to the foregoing, all of the glumes studied were examined for shoulder shape and beak shape. By assigning numerical values to the different shoulder shapes they were averaged and the means compared. Letting absent = 1, oblique = 2, round = 3, square = 4 and elevated = 5 the results shown in Table 13 were obtained.

TABLE 13.—*Comparison of shoulder shapes of different glumes on the largest spikes of Marquis plants grown in 1926.*

Glume examined	Mean	Range
Primary of 4th fertile	2.7	oblique (2) to round (3)
Secondary of 4th fertile	3.6	round (3) to square (4)
Secondary of 4th	3.6	round (3) to square (4)
Secondary of 7th	3.5	round (3) to square (4)
Secondary of 13rd	3.6	round (3) to square (4)
Secondary of 8th fertile	5.0	square (4) to elevated (5)
Secondary of 12th	4.0	elevated (5)

The shoulder shapes of the "primary of the fourth fertile", the "secondary of the eighth fertile and the "secondary of the twelfth" are not what is described as, or generally considered to be, typical of Marquis. (See Figure 6.) The "primary of the fourth fertile" is fairly representative of the primaries of other spikelets on a spike, consequently it may be stated that the shoulder shape of a Marquis primary glume is not typical of the variety. The shoulder shapes of the "secondaries of the fourth fertile, the fourth, the seventh and the one-third distance from the base" spikelets are much alike. All of the glumes that were examined had acute beaks. Minor variability in the degree of acuteness was observed.

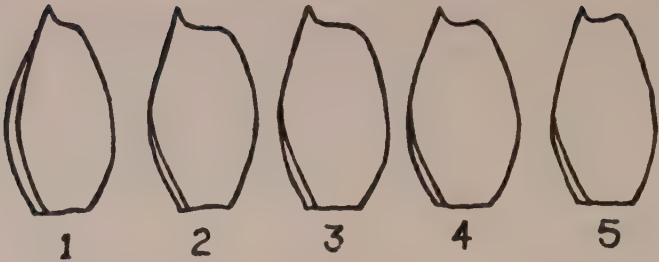


FIGURE 6: Representative glumes from different parts of a Marquis Spike: 1—the primary of the fourth fertile spikelet from the base of the spike. 2—the secondary of the same spikelet. 3—the secondary of a spikelet one-third the distance up from the base of the spike. 4—the secondary of the eighth spikelet from the base of the spike. 5—the secondary of the twelfth spikelet from the base of the spike.

The results shown in Tables 10 to 12 may be considered on the basis of the order of magnitude of the variability coefficients for the various glumes used, as an aid to visualizing their comparative standings. In Table 14 the different glumes have been assigned numbers to represent their rank for variability for each character studied. For example, the “secondary of the fourth fertile” had the lowest variability coefficient for glume length, the “secondary of the eighth fertile” had the next lowest variability for that character, and so on.

TABLE 14.—Ranking of the different glumes with respect to their variability for each glume character studied.

Character	GLUME MEASURED						
	Primary of fourth fertile*	Secondary of fourth fertile	Secondary of fourth of fourth	Secondary of seventh	Secondary one-third up from base	Secondary of eighth fertile	Secondary of twelfth
Glume length -----	5‡	1	7	3	4	2	6
Glume width -----	6	1	7	3	2	4	5
Shoulder width ----	7	3	6	5	1	2	4
Beak length -----	6	5	4	3	2	7	1
Beak width -----	4	6	7	1	3	5	2
Totals -----	28	16	31	15	12	20	18

\* See footnote of Table 12 for meaning of these expressions.  
‡ These figures indicate the ranking, viz: 1 represents the lowest and 7 the highest variability for the character under consideration.

The low variability of the secondary glumes of the “fourth fertile”, the “seventh” and the “one-third up from base” is shown clearly. Likewise the high variability of the “primary of the fourth fertile” and the “secondary of the fourth” is apparent.

The comparative reliability of the different glumes also may be measured statistically by using “Student’s” method on the coefficients of variability.

Since the coefficients for some characters averaged much higher than for others, it was necessary first to express each coefficient as a percentage of the mean of the coefficients for the character concerned. It was found that the “secondary of the one-third up from the base” was less variable than the “secondary of the fourth” by odds of 63.5 to 1, and not significantly different in variability from the “secondary of the eighth fertile”, the odds being only 8.6 to 1.

The results shown in Tables 10 to 13 warrant certain general conclusions. Glume length and width were the least variable of the characters employed. The primary glume of the fourth fertile spikelet from the base of the spike did not have the generally accepted Marquis shoulder shape and it was high in variability. The "primary" of the fourth fertile was selected as a typical primary glume; consequently the results indicate clearly that the "primary" should not be used.

The "secondary of the fourth" is high in variability of glume dimensions and therefore should not be used. This glume being so close to the base of the spike is influenced considerably by the extent to which the spike is developed. In a moderately dry season many Marquis spikes have at the base from two to five poorly developed spikelets, one to three of which usually are infertile. The number of infertile spikelets at the base is a fairly good index of the vigor of the parental plant. The size of the "secondary of the fourth" varied roughly in proportion to the number of infertile spikelets at the base. The correlation between the number of infertile spikelets at the base and the length of the "secondary of the fourth" was  $-.67 \pm .07$ . As a contrast to that correlation and to determine whether the "secondary of the fourth fertile" was at all influenced by the number of infertile spikelets at the base, the coefficient for the latter relationship was worked out. It was  $0.11 \pm .12$ , which indicates no correlation.

The "secondary of the eighth fertile" and the "secondary of the twelfth" do not show the typical shoulder shape although the former is only slightly extreme. It does not seem advisable to use either of these glumes in considering glume character.

"The secondary of the fourth fertile", the "secondary of the seventh" and the "secondary one-third the distance up from the base" are relatively low in variability for the characters studied, and possess the accepted shoulder shape of Marquis. In the size of parts they are closely alike. There does not seem to be any special advantage of one of them over the others.

There appear, then, to be several about equally reliable glumes to use in making exact descriptions of glume character. The "fourth fertile" usually was the sixth spikelet from the bottom of the spike. The "one-third up from the base" almost always was the sixth or seventh spikelet from the base. The "eighth fertile" generally was the tenth spikelet from the base (about the middle of the spike or slightly above that). Somewhere between the seventh and the tenth spikelets from the base, say the eighth would seem to be a safe upper limit to use. It would appear advisable, then, in studying Marquis, to employ the secondary glume of a spikelet approximately one-third of the distance up from the base of the spike, for that is a simpler procedure than taking a glume found by counting, and it appears to be as accurate.

Table 15 summarizes the glume measurements made on 30 spikes of Ceres. The glumes used were the secondaries of the fourth fertile, the fourth and the sixth fertile spikelets from the base of the spike. The results agree with those for Marquis and indicate that the "secondary of the fourth fertile" is more reliable than the "secondary of the fourth" for the measurement of glume dimensions. The sixth fertile spikelet from the bottom appears to be about as satisfactory to use as the "fourth fertile". A spikelet that is one-

TABLE 15—Comparison of the measurements of different glumes on the largest spikes of Ceres plants grown in 1926 using six characters.

Row of Table	Character	Glume measured	Mean in mm.	Range in mm.	Standard deviation	Coefficient of variability	Diff. in coefficients of variability between rows	Diff. P.E. <sub>D</sub>	No. of glumes m's'd
1	Glume l.	Sec. 4th fer.	7.76	6.8 to 8.3	.398	5.13±0.45			30
2	"	" 4th	7.39	5.6 " 8.0	.561	7.59±0.66	1 and 2=2.46±0.80	3.08	30
3	"	" 6th fer.	7.79	6.9 " 8.6	.399	5.12±0.45	1 " 3=0.07±0.64	0.01	29
4	Glume w.	Sec. 4th fer.	3.85	3.5 to 4.3	.199	5.17±0.45			30
5	"	" 4th	3.61	2.8 " 4.1	.272	7.54±0.66	1 and 2=2.37±0.80	2.96	30
6	"	" 6th fer.	3.85	3.3 " 4.3	.254	6.60±0.59	1 " 3=1.43±0.74	1.93	29
7	Shoulder sh.	Sec. 4th fer.	3.2	3 to 4					30
8	"	" 4th	2.9	2 " 4					30
9	"	" 6th fer.	3.5	3 " 5					29
10	Shoul. w.	Sec. 4th fer.	2.05	1.5 to 2.7	.252	12.29±1.07			30
11	"	" 4th	1.93	1.3 " 2.4	.283	14.66±1.28	1 and 2=2.37±1.67	1.42	30
12	"	" 6th fer.	2.05	1.5 " 4.7	.270	13.17±1.17	1 " 3=0.88±1.58	0.56	29
13	Beak l.	Sec. 4th fer.	2.58	1.8 to 4.3	.551	21.36±1.86			30
14	"	" 4th	2.42	1.6 " 3.6	.485	20.04±1.75	1 and 2=1.32±2.55	0.52	30
15	"	" 6th fer.	2.90	1.5 " 4.7	.708	24.41±2.16	1 " 3=3.06±2.85	1.07	29
16	Beak w.	Sec. 4th fer.	0.75	0.6 to 1.2	.147	19.70±1.71			30
17	"	" 4th	0.75	0.6 " 1.2	.161	21.50±1.87	1 and 2=1.80±2.53	0.71	30
18	"	" 6th fer.	0.67	0.5 " 1.0	.116	17.61±1.56	1 " 3=2.09±2.32	0.91	29

Note: Beak shape was acuminate (sharp) throughout.

third the distance up from the base of the spike falls usually between the fourth and sixth fertile spikelets from the bottom and would seem to be desirable to use here as with Marquis. This conclusion is probably applicable to all of the commonly grown wheat varieties of Western Canada, for Marquis and Ceres are fairly representative of them.

#### DISCUSSION OF RESULTS.

The 1220 separate progenies or lines of Marquis, Strain I, furnished interesting material for the study of the uniformity of pure lines and the significance of variations within and between them. The close resemblance of parent and offspring in certain spike and glume characters point to the possibility of identifying different strains of a variety on the basis of small differences. Of course the contrasting examples given in Table 7 do not illustrate typical differences to be found between strains of a fairly uniform variety, for Strain I is by no means homogeneous. Nevertheless it should be remembered that Strain I has for years been considered to be "reasonably uniform" and is accepted by most agriculturists, who have not made a careful examination of the strain, as an excellent standard strain of Marquis.

The clear cut difference between the two types of Strain I is demonstrated by the fact that in the sorting of the original 1220 mother plants according to type, in no case was a Type II plant classified as Type III or vice versa. The distinct difference in seed color and plumpness between these types and the many differences in morphological and physical character, as brought out in the comparison of Strains II and III in Part 1, offer further proof of the genetic dissimilarity of the types.

There is particular value in determining closely the correct method of measuring a wheat plant for glume character. As our agricultural requirements become more exacting and our experimental plot methods of testing

become more accurate it becomes necessary to draw finer distinctions than formerly. Naturally crossing, admixture and mutation all operate toward changing a variety by making it less uniform, less homogeneous. The adoption of the pure line method of crop improvement by a number of farmers and the use of this method by practically all experiment stations results in numerous strains of a single variety; these may differ morphologically as well as physically. The selector may choose for pure line propagation some plants that are non-typical of the variety with which he is working. If he chose a few such plants together with some that were typical, he might have a result like Strain I. If, however, he consistently chose off-type plants and none of the typical ones, he would no longer have the variety he started with, but something different. An actual example of this kind occurred in 1925. A farmer of Western Saskatchewan desiring to produce Elite Stock Seed ‡ from Marquis, Strain I, selected a number of what he considered were the best looking spikes. All of the progeny proved to be Type II, the non-typical type.

To tell a person to become familiar with the spike and glume characters of a variety is rather indefinite. The variability among the different spikes of one plant and among the many glumes on one spike is most confusing to him. But to refer him to the secondary glume of a spikelet a third the distance up from the base of one of the largest spikes on a plant is to give a definite direction of some value.

The use of more than 30 spikes of each variety for the determination of the right glume to measure would undoubtedly have resulted in lower coefficients of variability and probable errors, with different differences and probable errors of the differences than those appearing in Tables 10, 11, 12 and 15. Possibly some of the differences would show more significance than those obtained. Whether or not this would be true is unimportant, for the results on 30 spikes were sufficiently definite to show that secondary glumes approximately one-third of the distance up from the base of a spike gave as accurate results as other glumes nearby. They gave more accurate measurements than glumes near the base of the spike, or a typical primary glume and were more satisfactory to use than glumes near the apex of a spike, for the latter differed distinctly from those in the central portion of the spike where glume character is usually observed.

## SUMMARY.

### *Part 1.*

1. Fifteen strains, all supposedly of Marquis wheat, some pedigreed, others not improved, were compared for morphological and physical characters.
2. The nursery tests were made at Saskatoon in 1926, the series of strains being repeated fifteen times.
3. Milling and baking tests were made at Saskatoon and repeated at a Winnipeg laboratory.
4. For morphological study 200 plants of each strain were used. Some methods of measurement were investigated.

‡ "Elite Stock Seed" is the term used to designate the purest obtainable seed of a registerable variety according to the regulations of the Canadian Seed Growers' Association.

5. Nine strains proved to be typical Marquis and six non-typical. Two of the non-typical strains (I and X) were alike and consisted of two distinct types, one being Marquis and the other not Marquis. The other non-typical strains differed from Marquis in many respects.
6. The non-Marquis type of Strain I (II) was higher in yield and lower in milling and baking quality than the typical Marquis portion (III).
7. An unimproved typical Marquis strain (VII) contained mixtures and was high in proportion of off-type plants, in contrast to the improved strains (II, IV, VI, XII, XIII and XIV).
8. One non-Marquis strain (VIII) was very low in milling and baking quality.
9. The typical Marquis strains were all high in purity and trueness to type. They were similar in yield and milling and baking quality, displaying no important differences in these respects.

### *Part 2.*

10. As Strain I is widely grown in Saskatchewan a special study of 1220 individual plants was made on material grown in 1925. The plants were divided into three lots: Type II, the non-Marquis type; Type III, the Marquis type; Type A, plants belonging to neither of the foregoing types, being mostly intermediate in character.
11. In 1926 a progeny row from each plant was grown in the nursery.
12. With few exceptions the Type II and III progenies resembled their parents. In no cases did progenies from Type II plants prove to be Type III, or vice versa.
13. Most of the Type A progenies were more or less intermediate in character between Types II and III; some however proved to be Type II, others were Type III, a few were unlike either of these types.
14. It is probable that the Type A plants result principally from natural crossing between Types II and III.
15. Progeny plants resembled their parents fairly closely in the eleven spike and glume characters studied.
16. Types II and III were compared for seed color and plumpness using 61 and 117 lines, respectively. Type II was significantly higher in color score and lower in plumpness than Type III.
17. A detailed study was made to determine which glume to use in measuring glume characters of a plant. Two varieties were used, Ceres, an awned variety, and Marquis. The secondary glume of a spikelet approximately one-third of the distance up from the base of a spike was found to be satisfactorily accurate. The results did not show the necessity of using a glume ascertained by counting from the bottom of the spike. Primary glumes, and secondaries that were near the base or the tip of the spike were either not truly representative or else were too variable for accurate work.

## APPENDIX

*History of Strains.*

- Strain I.* Known as Sask. 7. Grown by the Field Husbandry Department of the University of Saskatchewan since 1911 when it was received from the Dominion Experimental Farm at Indian Head, Sask. Is unselected progeny of the original Marquis excepting in so far as it was altered unconsciously by field purification at Saskatoon as described in the discussion of Part I of this paper. Grown extensively in Saskatchewan having been distributed widely to farmers by the Field Husbandry Department at Saskatoon.
- Strain II.* Known as Sask. 7B. A mass selection of the dense type in Strain I made in 1925 at Saskatoon.
- Strain III.* Known as Sask. 7C. A mass selection of the typical Marquis type of Strain I made in 1925 at Saskatoon.
- Strain IV.* Known as Sask. 70. From a single plant selection of Sask. 7 made in 1914 by the Field Husbandry Department, University of Saskatchewan.
- Strain V.* Known as Sask. 944. Received from some farmer of the Northern wheat section of Saskatchewan in 1922 or 1923. Details of history lost in fire of 1925.
- Strain VI.* Known as 10B (Sask. 1221). From a single plant selection made from a stock of the original Marquis by S. Wheeler at his farm near Rosthern, Sask. in 1911. Registered by the Canadian Seed Growers' Association. Sold commercially by S. Wheeler and grown extensively in Saskatchewan.
- Strain VII.* Known as Sask. 1291. Obtained in 1925 from A. B. Perkins, Clark's Crossing, Sask., who procured it from A. W. Wallace, Sutherland, Sask. Mr. Wallace purchased his original stock of this strain from Winkler Bros. of Luseland in 1910 or 1911 when they brought in the first shipment of Marquis to reach Luseland. There is no record that any selection has been practiced in this strain since it came originally from Ottawa.
- Strain VIII.* Known as Sask. 1292. Received from some farmer of the northern wheat section of Saskatchewan in 1923. Details of history lost in fire of 1925.
- Strain IX.* Known as Sask. 1293. Received from some farmer of the northern wheat section of Saskatchewan in 1923. Details of history destroyed in fire of 1925.
- Strain X.* Known as Sask. 1408. Obtained from A. E. Dowling, Luseland, Sask., who had purchased his original stock in 1923 from the Field Husbandry Department, Saskatoon, as Sask. 7.
- Strain XI.* Known as M.A.C. 5 (Sask. 1424). Obtained in 1925 from W. T. G. Wiener, Manitoba Agricultural College, Winnipeg, Manitoba, who received it in 1914 from the Dominion Experimental Farm, Brandon, Manitoba, as a stock of the original Marquis. It is unselected excepting for the roguing out of admixtures.

*Strain XII.* Known as Mitchell's strain (Sask. 1607). Received from J. C. Mitchell, Dahinda, Sask., in 1925. A strain resulting from mass selection made in a stock of the original Marquis. Registered by the Canadian Seed Growers' Association and grown extensively in Saskatchewan.

*Strain XIII.* Known as 0-15 (Sask. 1609). Obtained in 1925 from the Dominion Experimental Farm, Rosthern, Saskatchewan, which had received it from the Central Experimental Farm, Ottawa. From a single plant selection made from the original Marquis at Ottawa by C. E. Saunders. Registered by the Canadian Seed Growers' Association and used extensively in Saskatchewan.

*Strain XIV.* Known as Lang's strain (Sask. 1610). Obtained from the MacKay Seed Farm, Indian Head, Sask., in 1925. Result of a single plant selection made in 1915 by W. D. Lang of Indian Head from a stock of the original Marquis which he received from C. E. Saunders of Ottawa in 1911. Registered by the Canadian Seed Growers' Association and grown considerably in Saskatchewan.

*Strain XV.* Known as Sask. 1639. Received from a Saskatchewan farmer in 1925. Details of history destroyed in fire in 1925.

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# THE CYTOLOGY OF CERTAIN HYBRID WHEATS, MARQUILLO AND H - 44 - 24.

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## INTRODUCTION.

Extensive crossing studies lead von Tschermak (2) to classify species of wheat by their genetic relations into three groups,—Einkorn group; Emmer group; Spelt group.

The Einkorn group contains two species, *Triticum monococcum* and *T. aegilopoides*. The emmer group consists of *T. dicoccum*, *T. durum*, *T. turgidum* and *T. polonicum*... The spelt group consists of *T. spelta*, *T. vulgare* and *T. compactum*. Numerous interspecies wheat crosses have been made in an attempt to combine rust resistance of the emmer group with the economic qualities found in some of the members of the spelt group, but partial sterility was obtained and at present it is not definitely established what to expect in second and successive generations.

Since 1918 when Sakamura (5) established the chromosome numbers of the different groups of wheat as 7 for the Einkorn group; 14 for the emmer group and 21 for the spelt group, cytological studies have been made and the causes of sterility between species in different groups is well established as due to difference in chromosome number or incompatibility of chromosomes. Papers published by Kihara (3), Sax (6), Watkins (8) and Thompson (7) describe the general behaviour of the chromosomes in plants from such crosses. Most of the segregates show sterility or partial sterility. The genetic evidence shows that there are great factorial differences of the chromosomes of wheats belonging to the emmer group and those of the spelt group, and by some there is great doubt as to whether a fertile segregate can be obtained containing both emmer and *vulgare* chromosomes.

Marquillo from a Iumillo  $\times$  Marquis cross by H. K. Hayes of Minnesota, and H-44-24 from a Marquis  $\times$  Yaroslav Emmer cross by H. S. McFadden of South Dakota are two relatively stable segregates which exhibit both emmer and *vulgare* characters, and, therefore, must have a chromosome complex derived from both parents. This study was undertaken to find whether these wheats act normally from a cytological standpoint.

## LITERATURE REVIEW.

Winge (9) made a cytological study to see if there were any chromosome irregularities which would account for the complicated ratios obtained by Nilsson Ehle, Vestergaard, Akerman, Linhard, and Kajanus in some speltoid heterozygotes and similar mutant types and gave a very reasonable explanation.

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†Investigations carried out in the Department of Botany at the Manitoba Agricultural College. Professor V. W. Jackson, my advisor, has given freely of his time. Dr. A. Savage kindly allowed the use of his photomicrographic apparatus and gave much advice on technique. The Rust Research Laboratory kindly supplied material. Dr. C. H. Goulden of that institution has given helpful suggestions.

## Theoretical Chromosome Relationships in Wheat Species Groups.

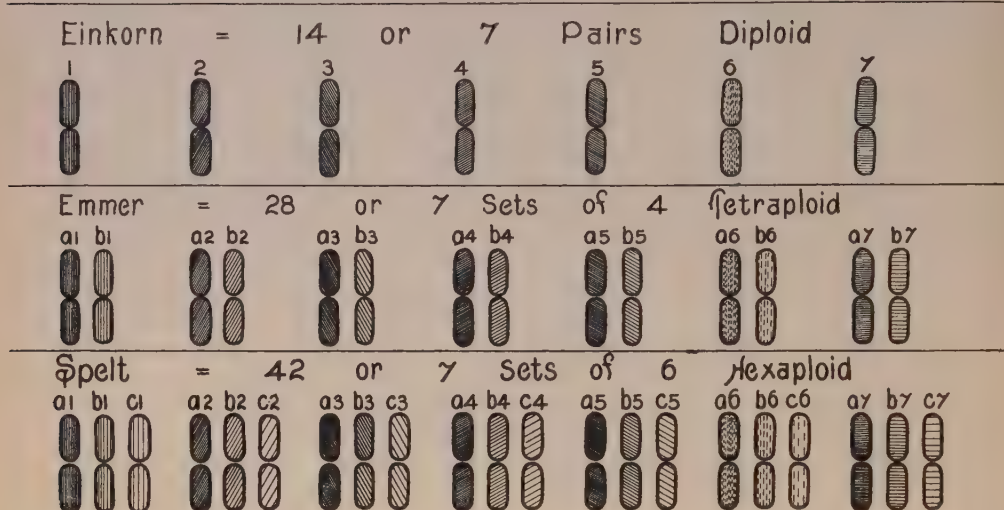


Figure 1.

According to Winge's conception the Emmer and *vulgare* groups containing 14 and 21 chromosomes respectively arose by reduplication of the chromosome complement of the initial or primitive wheat which contains seven pairs. Taking seven pairs of homologous chromosomes as the primitive ancestor, the emmer group would have seven sets of four somewhat homologous chromosomes and the spelt group would have seven sets of six somewhat homologous chromosomes according to the chart, Fig. 1.

In normal reduction and division of the spelt group an *al* chromosome would line up on the equatorial plate at the metaphase of the heterotypic division with an *al*, a *bl* with a *bl* and a *cl* with a *cl*. Sax describes the normal divisions in *vulgare* types and shows 21 normal bivalent chromosomes in a polar view of the equatorial plate. In the mutant material Winge found some trivalent and tetravalent chromosomes and decided that he had obtained abnormal pairing of the more or less homologous chromosomes.

When these trivalents are found, it is reasonable to suppose that the remaining univalent chromosomes will lag behind and one would expect irregularities in the usual ratios obtained from the inter-action of factors located in the chromosomes concerned. Goulden (1) used Winge's hypothesis as the basis for his explanation of dwarfing in wheat.

## MATERIALS AND METHODS.

Reduction and division was studied from the microspore mother cell to the breaking up of the tetrads in Marquillo and some first generation material of a cross H-44-24 × Marquis. Material of these three was collected at random from plants as they came to the proper stage. Anthers containing cells in the meiotic division were located by Belling's iron-aceto carmine method. Material for permanent mounts was killed and fixed in Allen's modification of Bouin's solution. Sections were cut ten microns thick by the paraffin method and stained in Heidenhain's iron-alum haematoxylin.

## MARQUILLO.

In Marquillo the characters of the *vulgare* parent predominate but it carries a yellowishness of the endosperm, a slight brittleness of the rachis and hardness of the glumes common to certain *vulgare* segregates from crosses between durum and *vulgare* types. It also carries part of the Iumillo resistance to rust, though genetically impure for this character. (See 4).

The Marquillo, grown by the Dominion Rust Research Laboratory at this college, was selected from plants grown from seed of Marquillo obtained from the Minnesota Experiment Station and Brandon Experimental Farm. In 1925 Dr. C. H. Goulden made 110 head selections. Each selection was grown in a five foot plant row in 1926 and notes taken on each row with regard to its rust reaction and general morphological characters, the plants being classified in each plant row for rust re-action as: resistant, partially resistant, and susceptible. For morphological characters a note was taken as to whether or not each line seemed to be breeding true and were classified as: pure, or breaking-up. In 69 of the lines all the plants were resistant to rust and were morphologically pure. In 25 of the lines approximately 1.5 per cent of the plants in each line were susceptible to rust. In 16 of the lines the notes showed that approximately 25 per cent of each line were susceptible. These 16 lines also showed that the morphological characters were very variable.

The object of this study was to find whether this segregation of morphological characters and rust resistance found in these lines was due to aberrant behaviour of the chromosomes in the meiotic divisions. If any chromosomes lag in either the heterotypic or homotypic division and are subsequently left outside of the nucleus at interkinesis and tetrad formation or abnormal pairing occurred we would expect irregularity in the breeding behaviour. Cytological material was selected at random from 78 plants.

In Marquillo the spireme stage at the prophase of the heterotypic division seems quite normal (Fig. 1, Plate 1). At the time of diakinesis, homologous chromosomes can be seen twisted about each other, but the total number of pairs at this stage is hard to ascertain with any degree of accuracy (Fig. 2, Plate 2). However, it is certain that there are approximately twenty-one of them arranged around the nuclear membrane. The pairs of homologous chromosomes shorten and thicken into bivalent chromosomes, the nuclear membrane disappears, a bipolar spindle forms, and the chromosomes line up across its center (Fig. 3, Plate 1), which shows distinctly 21 normal bivalent chromosomes (Fig. 4, Plate 1). The division proceeds; one homologous chromosome goes to one pole and the other to the other pole (Fig. 5, Plate 1). An occasional lagging chromosome is found on the spindle, at the telophase stage. In the telophase stage 226 cells were observed; 219 of these were normal, and 7 showed a single lagging chromosome. By the time of interkinesis no trace could be found of any lost chromosomes. 189 cells were examined and all were normal. The observations indicate that any chromosomes seen lagging at the telophase reached the pole before the nuclear membrane was formed and were included in their respective nuclei. Thus the heterotypic division of Marquillo seems quite normal.

The homotypic division takes place almost immediately. Of 160 cells examined at the telophase of the homotype, one showed a single lagging chromosome (Fig. 7, Plate I) and 162 were normal. This single lagging chromosome was on the spindle and near to the mass of chromatin at the pole, and would most likely be included in its respective nucleus. No traces of any lost chromosomes could be found at the tetrad stage. Two hundred and twenty-seven tetrads were examined and all appeared normal (Fig. 8, Plate 1). These observations point to a normal behaviour of the chromosomes of Marquillo.

#### H-44-24 $\times$ MARQUIS.

H-44-24 is a segregate from a Yaroslav-emmer cross  $\times$  Marquis. It carries the rust resistance and awns of the emmer parent. It seems to be a true breeding segregate and appears to be entirely stable so it was considered that its chromosome complex should act normally. Whether or not its chromosomes are compatible with other *vulgare* types was a question. This was especially so in view of the fact that it carries emmer characters and therefore, must have either part or whole emmer chromosomes in its germinal complex. Cytological material was collected at random from a large population of  $F_1$  plants of an H-44-24  $\times$  Marquis cross.

In general, lagging chromosomes were far more frequent in both heterotypic and homotypic divisions of this material than in either normal Marquis or Marquillo. In two cells a univalent chromosome was observed on the metaphase plate with the bivalents. At the metaphase of the heterotypic division Fig. 11, plate II, shows a trivalent chromosome lagging at this time. However, all the lagging chromosomes were reincluded in the nuclei of the tetrads as no trace could be found of lost chromosomes in the cytoplasm of the tetrads examined (Fig. 16, Plate II).

The above observation: lagging univalents and trivalent chromosomes, would indicate that abnormal pairing occurs of the more or less homologous chromosomes in the  $F_1$  when H-44-24 is crossed with Marquis in a similar manner as that described by Winge (9) and Goulden (1). Whether this is the case or not will be found out by the segregating ratios from these plants in the future generations. Should the chromosomes carrying rust resistant factors be acting in this manner when crossed with other *vulgare* wheats complicated ratios will be obtained but they will be explainable in the light of these cytological irregularities.

#### SUMMARY.

1. A cytological study was made of Marquis, Marquillo and some  $F_1$  material from a H-44-24 Marquis cross to find whether Marquillo might be expected to breed true in the future and whether H-44-24 would be expected to give regular ratios when crossed with other *vulgare* types.
2. The cytological behaviour of Marquillo seems to be quite regular, there being 21 normal bivalent chromosomes at the metaphase of the heterotypic division so that from a cytological standpoint indications are that it will breed true.

3. H-44-24 when crossed with Marquis shows an abnormal pairing of the chromosomes at the metaphase of the heterotype and, therefore, one would not expect the usual known ratios.

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WINNIPEG, MAN.

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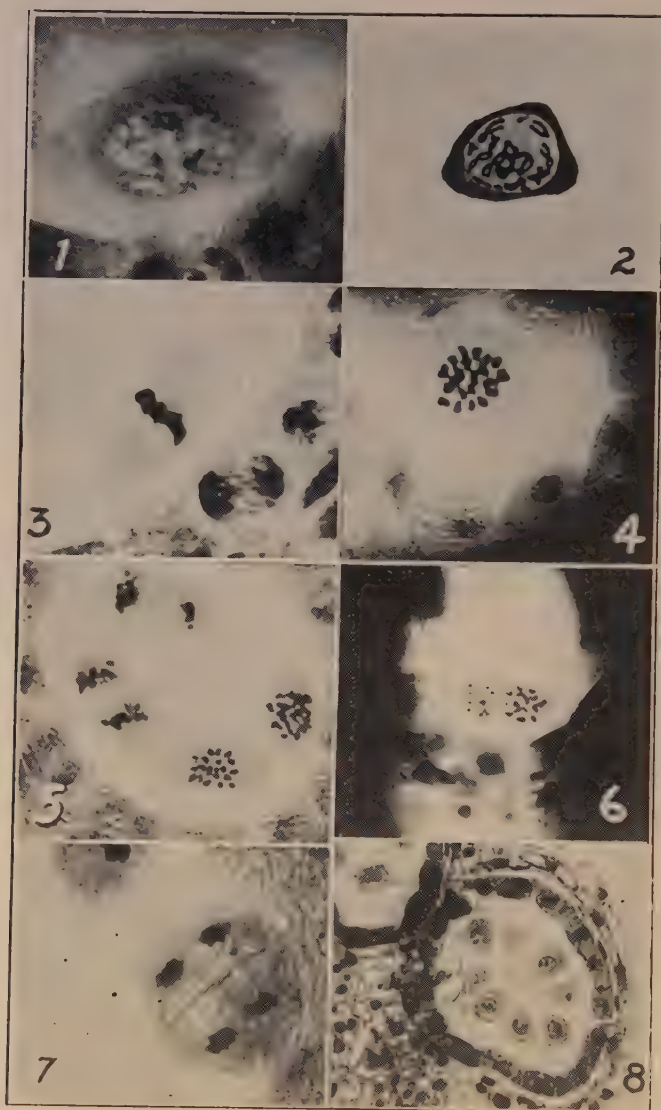


PLATE I.

(Microphotographs with the exception of Fig. II)

1. Pollen mother cell of Marquillo, early prophase stage.
2. Pollen mother cell of Marquillo, in diakinesis.
3. Pollen mother cell of Marquillo, metaphase of the heterotypic division.
4. Pollen mother cell of Marquillo, polar view of metaphase of heterotypic division.
5. Group of pollen mother cells of Marquillo in anaphase of heterotypic division.
6. Microspore mother cells, polar view of metaphase of the homotypic division.
7. Tetrad stage of Marquillo.
8. Locule of anther of Marquillo showing microspores, just after breaking of tetrads.

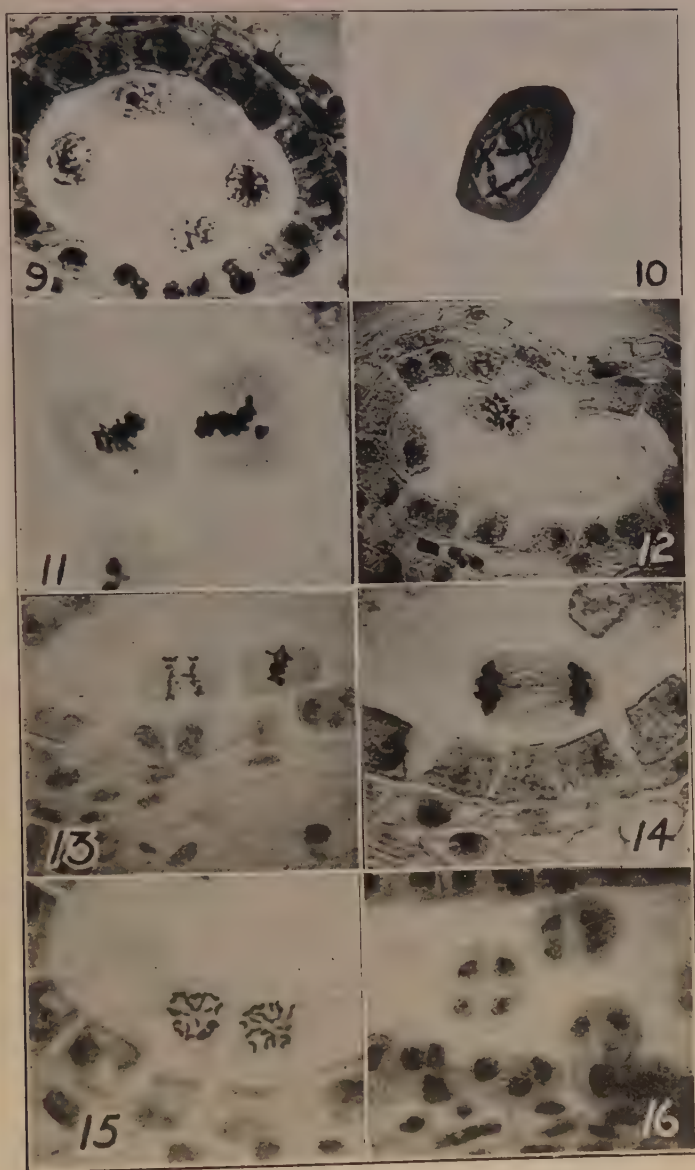


PLATE II.

(Microphotographs with the exception of Fig. 11)

9. Pollen mother cell of H-44-24 x Marquis, early prophase stage.
10. Pollen mother cell of H-44-24 x Marquis, diakinesis.
11. Pollen mother cells of H-44-24 x Marquis showing a lagging trivalent chromosome.
12. Pollen mother cell of H-44-24 x Marquis, polar view of the metaphase of the heterotypic division.
13. Pollen mother cells of H-44-24 Marquis, anaphase stage of the heterotypic division.
14. Pollen mother cell of H-44-24 x Marquis, telophase of the heterotypic division.
15. Pollen mother cell of H-44-24 x Marquis, polar view of the metaphase of the homotypic division.
16. Tetrad of H-44-24 x Marquis.

# INTRAVENOUS INJECTIONS OF COLLOIDAL CARBON IN HUMAN AND VETERINARY MEDICINE\*

R. L. CONKLIN

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Our knowledge regarding colloidal therapy is still in its infancy. Colloids have been used within the laboratory, but there are but few cases where they have been applied in the clinical field.

Interesting experiments have been carried out with vital dyes in the attempt to ascertain the physiology and structure of the cells of the body. Goldman (1) attempted to show that the dyes that he used in vital staining, were adsorbed and not phagocytized. Gay and Morrison (2) have demonstrated the influence of certain colloids upon phagocytosis. Tunnicliff (3) succeeded in proving that weak solutions of cholesterol have a beneficial effect upon phagocytosis whilst concentrated solutions inhibit this process.

We have other colloidal suspensions such as are employed in salvesan, where the results appear to be satisfactory, yet little is known as to the manner in which these results are obtained. Colloidal gold has been utilized by some (4) in the treatment of typhoid fever. Here too, only a theory is advanced as to the reason for its use.

Certain theories concerning immunity have long been assumed and no one seems willing to attack them nor to bring forth data not in agreement with these set rules. It seems that all phenomena must be explained by what we already know of body and cellular activity. The results obtained by colloidal therapy cause one to question, not only the theory, but the practice of immunity in some cases.

Some workers have employed colloids in suspensions with gum acacia as a protective colloid and their observations are very much alike. It was discovered that magnesium oxide (5) was rapidly removed from the blood by the liver, spleen, lungs and bone marrow. The same had been proven with carbon by Wislocki (6), who states that these particles are phagocytized by the clasmatoocytes. They assert that these organs possess a mechanism not present in other body structures, in the ability of their endothelium to phagocytize foreign material.

The work to be reported in this paper was started in 1921 as the result of laboratory experiments in the production of leucocytosis. It was noted that colloidal suspensions injected into the peritoneal cavity caused the migration of enormous quantities of leucocytes. The leucocytes infested the colloidal particles. Following this observation, the question arose regarding the possibility of producing this phenomenon by intravenous injections, especially in septicemic conditions. Theoretically, the carbon particles should incite phagocytosis of bacteria as well, after the increased number of leucocytes appear.

\*The foregoing paper was completed September 1st, 1923. Since that date considerable further research has been carried out and the material constantly employed as a routine treatment for conditions mentioned by the other veterinarians, with results consistent with those reported. Since work with this product is now being carried on by research workers in human medicine it has been considered advisable to publish this preliminary report at this time.

The material employed consisted of chemically pure colloidal carbon (*animalis*) suspended in distilled water. Protective colloids were not employed. Saline solutions were avoided in order to prevent the electrolytic action of the salt. Materials were autoclaved before use.

The bone was always cleaned free of meat and tendonous filaments before the charring was started. After charring the earthy salts were removed by concentrated hydrochloric acid. Following the removal of the salts, the material on the filter was washed clear of the acid. The particles were macerated in a sterile mortar and test suspensions were made to ascertain the average size of the particles. Usually we attempt to have the particles about one micron in diameter.

The amount of the material to be employed was determined by the weight of the individual. We found that a suspension of 0.001 grams per kilogram of body weight gave the best results (about 2%). Upon this basis the average sized horse received 50 c.c. of the suspension, whilst a man of 150 pounds should receive about 3 c.c. of the suspension.

All treatments should be given intravenously. In case of subcutaneous injections, large indurated nodules appear at the site of injection which recede only after several days or not at all. In large animals such as the horse and cow, the external jugular vein is the site selected for venesection.

The area is to be properly prepared by cleansing the skin and hair in the neck region. The hair may or may not be shaved. (I have seldom noted any disadvantage from the lack of shaving). The area of the puncture may be painted with alcohol or tincture of iodine.

The vein is then compressed below the point selected (i.e., near the cardiac end of the vein) in order to dilate the vein, and the needle forced into the lumen. One should be positive that the needle is well located by allowing the blood to pass from it before and after the operation, since the material injected about the vein will not give the expected results. The suspension should be allowed to run into the vein by gravity and with the inspiratory movements to insure that it mixes with the blood.

In man, the site of injection has been the basilic vein, since this is the most convenient site for venesection. As the amount to be injected is small, it may be given with a hypodermic. Care must be taken to withdraw a small quantity of blood into the syringe before injecting the suspension, to insure against the subcutaneous injection of the material.

The apparatus used in the treatment of large animals consists of the following—, a 50 c.c. pipette, about 10 to 12 inches of rubber tubing attached to the pipette, a small glass tube (window), tubing and adaptor to connect with the needle. (See Fig. 1).



Figure 1

The suspension is heated in a water bath to 37°C and well agitated before injection. The treatment is given with the material at blood heat and by gravity plus the flow of the blood to the thorax as caused by the respiratory movements.

Cases of superficial wounds, deep wounds and septicemia have shown the great benefit to be derived from colloidal therapy. Among the types of cases treated with this product are—, (a) joint-ill, (b) metritis, (c) lymphangitis accompanied by running sores, (d) calk wounds, (e) mastitis, (f) septicemia resulting from the use of a septic milking tube, and (g) abscess formation in man.

Over one hundred cases have been treated among domestic animals with complete success and without a single fatality. No animal has suffered from the treatment. In the human species it appears that the same results may be obtained and that colloidal suspensions of carbon should have a wide field of application. (See case report number four.) A very notable fact in connection with this method of treatment, is the absence of the “negative phase”, (i.e., the period after the injection of a biological product such as a vaccine or bacteria during which the resistance of the animal remains at a standstill or is actually reduced), following the treatment and preceding the beneficial effects. Even the most severe case treated responded within the usual time. There is a very rapid appearance of an increased number of polymorphonuclear leucocytes. In blood smears taken from treated animals two minutes following the injection, it is often difficult to locate the polynuclear cells. In three, four and five minutes, however, the increased numbers exhibit a distinct contrast. The smears were stained with Wright’s stain. In the smears taken at five minutes, there was little difficulty in obtaining from three to six polynuclear cells in a field. These cells are not only increased in numbers but also in activity as observed by the taking up of colloidal particles.

Following the intravenous injection of colloidal suspensions there is a rise of temperature which is followed by a return to normal. This elevation of temperature is accompanied by a slight increase in respiration and pulse rate. The above symptoms are complete within the first hour. There is no danger or inconvenience from the operation and it is always followed by a notable improvement.

Many cases of highly septic conditions, such as joint-ill of foals, have recovered following this treatment. Such cases are usually considered beyond medical assistance, as in case number one, where the animal had not received nourishment for three days and was unable to rise. The temperature and pulse give some indication as to the extent of the infection. At the end of the fourth day following the treatment the animal was able to get up without assistance.

This colt made an uneventful recovery and has developed into an outstanding individual, taking first prize in his class wherever exhibited.

In the laboratory, we have attempted to make blood counts in some cases before and after injection. These counts have shown the enormous

increase in the number of polymorphonuclear leucocytes. Not all cases were recorded in this manner since it was not possible to have the proper assistance at all times.

The animals employed were actual cases and not experimental animals. We have made smears from the blood at various periods following the injection. These smears exhibit the facts substantiated by the actual counts though the method is not as accurate. (Some studies have been made upon the opsonic index. In the cases that were studied, the opsonic index was increased.)

Rabbits were employed to ascertain the danger from embolisms when colloidal particles of one micron in diameter are introduced into the blood stream. Some of the experimental animals received as much as 35 c.c. of the suspension in the ear vein. No harmful effects were ever observed. If it is possible to give a small rabbit 35 c.c. of this suspension in the ear vein, there should be absolutely no hesitancy in giving a large animal 50 c.c., or a man 3 c.c. of the same suspension. Further, anaphylaxis will not follow as the material is free from proteins.

One cannot give a true picture of the changes which have taken place in the bodies of the animals treated, since all animals so treated have recovered. We must then, refer to the rabbit to study the disposition of the colloidal suspension. Rabbits were injected in the ear vein and killed by pithing at intervals, from three to twenty-four hours after the operation. Smears and sections were made from the liver, lungs, spleen, kidneys, and bone marrow of some of the long bones.

It has been observed by this method that the carbon particles become phagocytized by the endothelial cells of the liver, spleen and lungs as stated by Wislocki (6). These cells apparently have a special function, since it has been shown by other observers that ordinary epithelium is permeable to vital dyes, but the liver, spleen and bone marrow have the property of storing these dyes within their cytoplasm. The endothelial cells of the above mentioned organs are actively phagocytic to all forms of suspended material.

Leucocytes which have become loaded with colloid apparently undergo degeneration and disintegration and cast the colloid particles back into the blood stream. These colloid particles again become phagocytized. In cases of rabbits with organs showing signs of parenchymatous degeneration, colloidal particles may be observed within the cytoplasm. This condition has been observed in diseased livers, once in the kidney and once within the uterus of a female a few days after parturition.

We have nothing definite to report as to the method or manner in which the colloidal carbon produces its beneficial effects. It may be due to the simple law of adsorption as expressed by 'Gibbs Theorem' (ie. a substance is positively adsorbed if it depresses the surface tension, and negatively adsorbed if it raises the surface tension.) Adsorption also depends upon the surface development of the dispersed phase. This colloid should not experience any great difficulty in the blood stream since it merely becomes another phase in a system of colloids.

When the colloidal, suspension of carbon is added to a culture of bacteria in the laboratory, the bacteria are precipitated. The pseudo-agglutination has also been observed in hanging drop preparations of the above mixtures. These facts may be explained by adsorption. When the suspension is introduced into the blood stream other factors must be considered.

It is suggested that the carbon particles adsorb the agglutinins from the serum and may thus produce agglutination of the bacteria. When this has taken place the bacteria and the carbon particles are easily phagocitized. The bacteria are digested by the phagocytes and the carbon particles remain inert masses. In this respect the carbon acts not only by its power of adsorption but as a protective colloid as well. It may be that this process takes the place of the so-called opsonins, hypothetical substances, said to increase the appetites of the phagocytes.

On the other hand the action may be purely physiologic, in stimulating and reinforcing the defence organisms of the body. The stimulating of the endothelial cells of the liver, spleen, and bone marrow to throw more leucocytes into the circulation and thus to overcome disease, appears as another possibility. In this we may be producing an exaggeration of normal or natural conditions and bring about in one hour the effects usually obtained in twelve hours.

#### CONCLUSION.

1. Suspensions of colloidal carbon have a place in colloidal therapy as applied to human and veterinary medicine.
2. The material should be given in small quantities, intravenously and at blood heat.
3. The field of application includes cases of septecemia, and pyogenic infections of any nature whether superficial or deep.
4. Colloidal suspensions of carbon are absolutely harmless in the hands of competent medical men and insure excellent results when properly administered.
5. Finally, the low cost price, the efficiency of the product, its universal application in the relief of distressing symptoms, together with the shortening of the period of the illness and suffering, are worthy of the most careful consideration.

#### SUMMARY.

The suspension of colloidal carbon has been used very successfully and extensively in the treatment of over one hundred cases of septecemia, (joint-ill), metritis, mastitis, lymphangitis, and external pyogenic wounds. It has been employed chiefly in domestic animals but has been used in man as well.

It is suspended in sterile water in the absence of protective colloids in order to increase its sensitiveness. It may be sterilized without danger of alteration. If suspended in a saline solution, flocculation might occur due to the electrolyte.

This suspension has the distinct advantage over colloidal dyes in that it is not toxic, and the results obtained justify its practical application. It has been used successfully for over three and a half years without a single fatality.

Colloidal therapy has many things in its favor over the routine serological treatment by vaccines, bacterins, etc., the most outstanding of which we will name. The dose of colloid to be administered is very small. The 'negative phase' is absent, and the period of disease is shortened.

The chief facts noted following treatment with colloidal carbon are (a) increase in numbers and in action of the polymorphonuclear leucocytes, (b) elevation of the temperature followed by a return to normal, the maximum being reached within an hour, (c) recovery of the patient, the external signs of improvement being noted by the fourth day in case of pyogenic infections.

#### APPENDIX.

In the appended case reports, only representative cases have been selected. It would be useless for one to consume time and space by duplication. We will therefore give a detailed account of a case of "joint-ill" or "navel-ill", a septicemic type of disease; one of purulent metritis; one of mastitis; one of external suppurating wound; and lastly, one of abscess formation of man.

##### CASE No. 1: CLYDESDALE COLT OWNED BY J.B.C.

This colt had been down for four days, and "joint-ill" was diagnosed at the time of examination.

The mare and foal were in an old barn which was dark and poorly ventilated. The mare had been allowed to foal upon chaff and dirt for litter. The colt was slightly premature.

The temperature of the foal was 107.00 F, the pulse 140 and the respirations were 40 per minute. The colt was stretched out upon the floor and unable to raise its head. It had not taken food for three days.

A large abscess, measuring 6 inches in diameter, was present at the angle of the right jaw; another abscess was located over the navel. The latter was about four inches in diameter, hot and painful. The left hind leg was swollen from the hip to the foot. This swelling of the limb was very "doughy" and retained the imprint of the fingers for some time. The circumference of the hock was eighteen inches. Oedema of the sheath was also observed. The owner was advised that the colt would die under usual treatment. Permission was then given to use the colloidal suspension.

The colt was given 30 cc. of the sterile suspension in the external jugular vein. After observing the colt for one hour the following points were noted:—the temperature increased to 107.5, pulse 160, local perspiration over neck and abdomen, followed by urination.

This colt was given 30 cc. of the suspension on each of the two succeeding days. The internal treatment consisted of the administration of stimulants and tonics only. A very notable reduction of the T. R. and P. were observed on the third day. The animal was able to arise with very little assistance. On the fourth day the animal was able to arise alone and to nurse. The abscesses were not incised.

Two weeks after the treatment the foal had recovered sufficiently to be able to run about out of doors.

That the recovery was complete is shown by the ability of this individual to win in the show ring.

##### CASE 2: CASE OF PURULENT METRITIS.

Cow aborted and retained the afterbirth. The afterbirth was removed manually after 48 hours. Purulent metritis followed, accompanied by the usual symptoms.

Cases of this character received from 30-50 cc. of the colloidal suspension. The purulent discharge invariably ceased by the fourth or fifth day. Animals treated by this method when bred at the second period of oestrus following the injection, have conceived and given birth to healthy, viable calves. Some cases have borne two calves since treatment.

### CASE 3. MASTITIS.

Animals with various forms of mastitis have been treated with suspension. Probably the most notable cases fall into the class of infectious mastitis, though the form known as parenchymatous mastitis responds equally well.

The case to be quoted was treated by a practising veterinarian after all other treatment had failed.

The animal was a heavy producing Ayrshire, suffering from infectious mastitis. Among the early symptoms were:—anorexia, fever, purulent material appearing in the secretion of milky enlargement of the udder in the nature of an acute inflammation.

The animal was given the formalin treatment as recommended by Frost, oil of camphor *per subcutis* and local treatment to the udder.

The condition became very serious, and after the animal had become greatly emaciated and unable to stand upon its feet, the writer was called in consultation. The use of colloidal carbon suspension was recommended.

The animal recovered completely without loss of function of any part of the udder.

### CASE 4: PYOGENIC INFECTION (ABSCESES) IN MAN:—

The presence of boils following infections from various sources may also be treated by this method. Mr. B. had been troubled with boils for over eighteen months following an operation for removal of a ruptured appendix. He had about one boil a week.

After observing the effects of this treatment upon several animals, Mr. B. desired to try its effects upon his condition. At the time of injection a large abscess was present upon the right knee.

The basilic vein was compressed by aid of the sphygmomanometer, the arm properly cleansed and one cc. of the material given intravenously.

Mr. B. stated that he had a headache for about one hour after the treatment, but observed no other ill effects. Though the abscess was not incised, it disappeared before the fourth day. A letter from Mr. B. informs us that he has not had an abscess since. The treatment was given about 18 months ago.

(This case was treated by our local physician, Dr. R. F. Kelso).

### CAE 5: BAY HORSE CALK WOUND AT CORONARY BAND. (CASE OF SKIN QUITTOR).

The condition of this animal followed from a treated wound produced while standing in the stable during convalescence from a severe laceration of the thigh. The area above the coronary band exhibited an acute hot and painful swelling accompanied by swinging leg lameness.

This abscess formation was opened with a bistoury, cleansed with a 5% solution of phenol showered with cold water and dressed daily. When the acute inflammation had abated, heat and poultices were used. The wound was cleansed daily with warm saline solutions.

The condition persisted, and no results could be observed even after two weeks of treatment. At this time the animal was given 50 c.c. of the suspension of carbon. Local treatment was discontinued.

On the third day following the treatment, the animal was able to place its foot upon the floor. By the end of one week the animal was used in a three-horse team.

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## THE RELATION OF SCIENCE TO AGRICULTURE\*

H. G. L. STRANGE

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Since I have, for several years past, made it my business to attempt to discover some of the reactions that are actually going on in the farmer's mind and heart, perhaps I may be permitted to act as an interpreter of the usually inarticulate longings, desires and queries of the average farmer toward the science of agriculture.

I want it to be fully understood, at the outset, that nothing I say in this address is intended to give the impression that I am not in sympathy with experimental work or experimental institutions. I will not take second place to anyone in my sincere admiration for such work and such institutions. I am strongly in favor, not of fewer experimental institutions, but of more; not of fewer men engaged in research to reduce costs of production, increase quality and yield, etc., but of more; not of less money spent for this work, which is so vital to the welfare of Canada, but of much more. If you believe that, you will still meet me in as friendly a way as you have done in the past when I come to sit at your feet for knowledge and inspiration.

If a member of some other profession, knowing nothing whatever of agriculture, saw the words "Scientific Agriculture," "Bachelor of Science of Agriculture," "Science of Agriculture," he would assume, if he knew his Latin, that such terms referred to a business or industry of which the fundamentals at least were exactly and scientifically *known*. I may be unconsciously prejudiced in this matter. Most of my life has been spent in the business of engineering, which I think is generally admitted to be an exact science. When, some few years ago, I started into agriculture and saw the terms which I have quoted, I naturally imagined that agriculture would be a science in somewhat the same degree as engineering. I hope you will not be offended when I state that, to my intense amazement, I found that, broadly speaking and with certain reservations, the scientific part of agriculture consists of an ever growing tabulation and appreciation of things that are not definitely known rather than of things that are known.

I wondered to myself why the leaders in this profession had not been content to call agriculture an art, until, upon looking in the dictionary, I discovered that, while the word "Art" certainly includes many things which typify exactly the things which go on in agriculture, such as "The use or employment of things to answer some special purpose;" "The employment of means to accomplish some end;" "A system of rules to facilitate the performance of certain actions;" "Skill in applying such rules;"—yet I find also that perhaps you could not accept this word because of some other meanings which appear to be wedded to the definitions above given, such as "Opposed to nature;" "Opposed to Science;" worse than all I find, tucked

\*An address to the Alberta Branch of the Canadian Society of Technical Agriculturists, December, 1926.

away at the bottom of the explanation: "Artful;"—which really should mean full of art or the superlative of art, yet is really defined in the dictionary as: "Cunning," "Sly," "Deceitful," "Crafty." Perhaps it was this last definition that decided your founders to take a chance on the word "Science," feeling they would rather be open to criticism on this word than lay themselves open to the charge of being either cunning, sly, deceitful or crafty!

To my mind, engineering is a science because practically everything that has to do with the business of engineering can be weighed and measured, or at least estimated very accurately. For instance, take a small piece of metal; the subjecting of this metal to physical and chemical tests will enable one to calculate accurately and exactly how hundreds of thousands of tons of this very small piece of material will behave, whether it becomes part of an engine, a bridge, or any other mechanical contrivance. Or, if you will bring to a competent engineering chemist a sample of combustible matter, he can determine by his physical and chemical tests the exact amount of light, heat and power that is locked up in this sample of matter. He can calculate for you, accurately, just what can be done with millions of tons of this material and the cost of doing it, and you may, if you so please, invest millions of dollars, erect power plants, or other industrial concerns upon the calculations of this engineer. You would find that with ordinary good management, the results will turn out substantially as the engineer had indicated. Or, from examination of a piece of distillable matter, the engineer could inform you accurately as to the amount that could be won of dyes of different colours, of fertilisers, industrial gases, or indeed, of poison gases for use in the extermination of vermin or of men in battle, etc., etc. I think you will agree there is some excuse for calling engineering a Science.

Now consider agriculture. I, a very humble and knowledge-seeking farmer, bring to the scientific agriculturist, if you please, a milch cow, or a chicken, or a seed, or a pig, together with several samples of my soil and data as to my average rainfall, etc. I say: "I am about to take up the scientific pursuit of farming. Will you kindly put these animals that I am bringing you, these seeds of different plants, and this soil, all of which are my raw materials, through your laboratories, subjecting them to various physical and chemical tests and will you kindly inform me as follows: How much milk will this cow give next year? How many eggs will this pullet lay next year? What weight of product will I secure from these seeds at harvest if they are planted in the soils which I am presenting to you? Here are the data I have accumulated on rainfall, sunshine, evaporation, wind, hygrometrical and barometrical readings. To how many little pigs will this sow give birth next year?" I also tell you that I am willing to adopt any system of feeding and management and housing that you will recommend.

Now this is substantially the answer I receive from you: "It is perfectly easy. Build yourself a chicken house, according to the plan we will give you, equip the chicken house with trapnests, feed the chickens according to the methods herewith. At the end of the year you will know exactly,

if you have kept your records correctly, how many eggs the bird has laid in the preceding twelve months, and, following the same principle with the milch cow, you will know all about her milk yield after she has given it for twelve months. At harvest time, when your grain is in the bin, and your hay is in the stack, you will know exactly what your field crops have produced. When the sow has farrowed, you will know how many pigs she has given." And so on and so forth, gentlemen, throughout the realm of agriculture.

Now I put it very plainly and frankly to you, is this business a science, that is, the same kind of science that comes from the Latin word, *Scio*, I know? Of course, I must admit in all these instances, that you know eventually, but you know all the way from four months to a year late.

Now the questions I have asked here are comparatively very simple ones. Had I been a designing person and wished to complicate matters, I would have asked you some of these further questions:

What will be the size of the egg this pullet will lay next year? What percentage of her eggs, roughly speaking, will be fertile? Will her progeny lay as she laid? Will the eggs of her progeny be as fertile as her own eggs? Will the size of egg of her progeny be the same as hers? Will the number of eggs laid during the winter months by her progeny be the same as hers?

Here are two pullets, both full sisters. Same dam, same sire. One of these last year laid 250 eggs. The other, under identically the same management and feed, laid 125 eggs. Why?

Here is a cockerel whose mother laid 250 large sized eggs. How will the daughters of this cockerel perform?

And the answer, gentlemen, to most of these questions is that not only does no one know, but no one has even very much idea about it all.

Here are some still more difficult questions:

What makes one hen transform her feed into eggs and what makes the other hen transform identically the same feed into meat?

Why does one cockerel produce daughters that lay either abundance of eggs, or eggs of good size, or very fertile eggs, whereas the daughters of his full brother do these things most indifferently?

It is well known that on the day of incubation of a chick the ovary has produced all the yolks of the eggs that the future hen will ever lay. No hen ever lived to lay all the yolks that are present at the opening of her oviduct on the day she was hatched from the egg. Whether a hen is a high layer or a low layer these thousands and thousands of embryonic eggs are present. Now, why does not the hen lay all these eggs?

Further, how is the food given to the hen transformed into shell, egg albumen and yolk, all that go together to make a completed egg? Where does the yellow in the egg come from?

Let us take milch cows. Here are two cows. Both weigh the same. Both will be fed the same ration. Both are under the same management.

One will stay lean and give seven thousand pounds of milk in the year; the other will only give three thousand pounds of milk but will become quite fat. Why does one cow transform her feed into milk; why does the other cow transform her feed into beef? What has happened in the milk factory? What has happened in the beef factory?

Here are two young bulls. One throws high milking progeny, the other does not. Why?

What percentage of the little pigs from this sow and this boar will be of the select bacon type? Why does one sow average fifteen pigs to a litter and the other average only eight? Why does one sow produce select bacon offspring and the other, with the same method of feeding, produce thick smooth offspring?

Will this plant winter kill? Will this other plant survive droughts?

What is the best way to work this soil to give the greatest yield, to reduce the growth of weeds? What is the best way to treat it so as to get the highest quality of crop?

Exactly what is happening from the time the seed is planted up to the time the plant is harvested?

From a definite and scientific point of view, what makes the plant grow? It is said that micro-organisms in the soil transform certain minerals and other elements into solutions, or perhaps gases, that the plants are able to assimilate. Will you please write down, in chemical formulae, the exact reactions that are taking place?

I am not going to bore you, gentlemen, with any more of these examples, but how many of the above questions are scientifically and definitely answerable? I venture to say, very few.

But, you will say to me, for years and years we have been working steadily towards the solution of these very problems. I agree with you. As I see it, you have been attempting to find out which pullets laid the most eggs; which pullets laid the largest eggs; which pullets gave the most fertile eggs; which cockerels threw stock with the above attributes. And you have further experimented and endeavored to isolate inbred strains that would, in a more or less degree, do these things as long as their inbred vitality lasted. But you will pardon me for saying that it does not seem to me that you have spent very much time or money in trying to find out *why* these birds did these certain and definite things.

With the dairy stock, you have been isolating cows that gave the most milk and the richest cream and those that gave the most beef and the sires that produced a certain kind of stock. But it does not seem to me that you have spent much time in trying to find out *why* these dairy animals performed these various functions.

With plants, you have spent a lot of time and energy in isolating varieties and strains and families of plants that would give larger crops and higher quality crops or that were resistant to disease, but in this case, too,

only an insignificant amount of money and time has been spent on the real finding out of *why* these things happened.

It seems to me that, with a few exceptions, and speaking rather broadly, the science of agriculture is about on a par with engineering when engineering was in the crude stage before drafting and designing were known. Imagine a hole of a certain size bored in a piece of metal. Imagine an artisan being told to make a plug to fit this hole exactly. How will he do it? The old method was for the man to lay the piece of metal with the hole in it beside him, secure a plug of somewhat larger size than the hole, and proceed, with machinery or by hand tools, to whittle the plug down until, after numerous attempts of trying the plug in the hole, it finally fitted. This, in engineering, is called the fit and try, or trial and error, method. It does seem to me that a lot of our agricultural experimental work today is along this line.

The modern method in engineering is to give the artisan a drawing of the hole with the exact sizes marked on the drawing. The man is furnished with a micrometer, or some other very accurate measuring device, and he makes the plug to fit the hole without ever having seen the hole. And the plug fits. He can make thousands of plugs, all of which will be exactly right. Research science has come to his aid with a fundamental knowledge of accurate measurements and the laws of expansion and contraction of various metals under the influence of temperatures, etc., and has enabled that man to do a thorough and good piece of work almost automatically. It seems to me that today agriculture is to a great extent floundering around because it has not the advantage of much knowledge of fundamental science to help it. Observe, please, that the draftsman in the office, who designs these tools that I speak of, does not do away with the artisan. He merely makes his job easier and more accurate.

So, as I vision it, a knowledge of fundamentals in the science of agriculture would not curtail the work of the experimenter but would afford him a sound basis of exact knowledge upon which to perform his experiments.

As I understand it, fundamental biological research aims at finding out the whys and the wherefores. It aims to discover fundamental principles. When such principles have been firmly established, the scientific agricultural investigator is able to use them to put his work on a firmer basis, thus enabling the farmer to conduct his operations with more certain knowledge and profit.

In my own mind, I divide all experimental work into four groups: (1) Pure research work for the sake of the work itself, which may not be intended to have any immediate practical application; (2) Fundamental research work which has an immediate application if the principles are discovered; (3) Experimental work which has to do with verifying or putting into practical application the scientific truths or principles discovered by the research worker; and (4) Experimental work which has not the advantage of the help or knowledge of firm fundamental principles and which is hoping and aiming, by means of the so-called fit and try method,

to discover, not perhaps the why and the wherefore of things happening, but whether or not they do happen under given circumstances and conditions.

I have tried in my own mind to discover an example of the first class. I find it very difficult indeed to think of one. It seems to me that any knowledge of fundamental principles, sooner or later, may become useful. I thought, for instance, that the most exaggerated case imaginable would be that of a man who might allocate his lifetime and his energies to the exact, almost micrometrical measuring of the depressions in the moon, it being assumed, of course, that the moon is a dead object. But even here it is not beyond the realm of imagination to think that such a scientist in the course of his investigations might discover a new gas in the bottom of these depressions, might have to invent a new type of measuring instrument, or might, indeed, discover something entirely new about our planetary system, incidentally, whilst finding out why and how these holes were caused.

It appears to me that the great bulk of the experimental work we are engaged in today comes under class four. Obviously, if my contention is correct, we are sadly lacking today in that knowledge of biologic fundamental principles that I have outlined under class two, that is to say, principles of life that have immediate application to the happiness and prosperity of all experimental work and all agriculture as soon as they are discovered.

If we only knew the why and the wherefore of egg production, of milk production, of beef production, of plant growth, of soil growth, what a firm foundation our experimenter would have to work upon! It is common knowledge that the heterogeneity of soils commonly causes errors in results that are sometimes greater than are likely to be covered by any calculation of the probability of error. As I see it, we have but a hazy knowledge of the exact processes that are going on in the soil and influence the plant's growth.

Is it too much to expect of the biological chemist that he should some day have such a definite and complete knowledge of the whys and wherefores of processes that go to the producing of eggs or milk, that he could take a section of the tissue or a sample of the blood stream of these animals, subject them to laboratory tests and say, perhaps, that the glands or secretions or the acids, etc., that constitute the make-up of the digesting ability of these animals, are such that food will most likely be transformed into meat rather than eggs or into beef rather than milk? I cannot entertain any doubt that this is a reasonable goal for such a chemist to aim at.

Let me give some examples of the possibility of the deductions of experimental work being inaccurate because of the lack of knowledge of the fundamentals of biological truths.

For many years all kinds of experiments have been going on in regard to egg production. In turn investigators would announce great success with a certain feeding ration, while others would report no success with this ration. The same condition applied in the case of the fertility of eggs. Then it was suddenly discovered that the Ultra-violet ray factor contained in sunlight was the cause of greater variations in egg production and in the

fertility of eggs than was the difference between different feeds. This, it was afterwards found, had the same effect on the bird as did the so-called fat soluble D vitamine contained in cod liver oil. One does not require much imagination to realize the money and time that would have been saved in experimental work had a knowledge of Vitamine D, or the Violet ray, been known earlier.

Somebody might say that this difference could not have been the case in a feeding trial had check pens been used. This, of course, does not necessarily follow, particularly in the method of testing variety against variety, as, for instance, a black hen or a red hen against a white hen, where, under cloudy conditions, when little sunlight is available, the black or slowly absorbing colour might find itself on an equality with the white or quickly absorbing colour; or where, when both black and white birds are given a ration containing the Vitamine D, which apparently has the same effect as sunlight, both might perform equally. What I have said about poultry in this regard applies with equal force to animals, particularly to pigs, where black and white pigs are being tested against each other. A knowledge, however, of the exact effects on life of the ultra violet ray has made the work of the experimenter easier.

I have no doubt that some very important feeding trials have been made with cattle. I certainly know they have been made with pigs as to the relative merits of certain kinds of pasture for grazing purposes and of the relative merits of percentages of concentrates to pasture. Very elaborate conclusions have probably been drawn from these trials.

You are perhaps all aware of the recent important discoveries in the matter of the feeding value of grasses which have been made in England by the fundamental research worker and which would seem to put an entirely new complexion on experimental work in the feeding of pasture and hay to live stock. This is described in the *Journal of Agricultural Science* of April, 1926, the authors being Messrs. Woodman, Blunt and Stewart. It has to do with the feeding value of growing grasses and reveals the astonishing fact that young grass is more than twice as rich in protein as grass at haymaking time, and that this richness remains constant throughout the growing season provided the grass is kept closely cut or grazed. This growing young grass is also found to be more highly digestible than the best hay, palm kernel cake, barley meal, or cotton cake, and, in fact, is equal to linseed cake itself. Another point shown is that there is a considerable falling off in digestibility and nutritive value of herbage when it is allowed to continue growing until haymaking time, thus demonstrating that when pastures are allowed to continue growing they lose appreciably in feeding value. In fact, the authors declare that continually closely cut or grazed pasture grass may be regarded as possessing the character of a concentrate and possess the feature lacking in most concentrates of supplying the animal's requirements for vitamins, and, where legumes are mixed with the grasses, of supplying the animal's requirements for mineral matter. The authors state that it can therefore be asserted that the farmer's cheapest and possibly his best concentrated food is to be found growing within reach of his own homestead.

These principles apparently show clearly how many of our feeding trials may have gone astray. Consider, for instance, two sets of pigs in a feeding test to determine the amount of concentrates consumed with different amounts of pasture, or vice versa. Apparently, from the findings above mentioned, the final results would depend, not so much on the amount of pasture consumed, but on whether the pasture was sufficiently stocked with hogs to keep it quite short and well grazed, so that the pasture eaten by the hogs would be as high as possible in protein and contain the necessary vitamins. If, on the other hand, hogs were forced, by the elimination of concentrates, to consume pasture in a field of such size that the growth soon became rank, then they would be consuming a very much greater amount of mere roughage.

At the recent meeting of the Western Canadian Society of Agronomy, Professor F. A. Wyatt indicated clearly that, with certain soils at all events, the heterogeneity of almost adjacent plots gave a difference that has often been greater than the published differences of yields of comparative varieties. The whole matter of the heterogeneity of soils has been under careful investigation by the American Society of Agronomy, whose work was reviewed by the Dominion Cerealists, Mr. L. H. Newman. The American Society of Agronomy unquestionably considered that the matter requires a great deal of further research and study.

It seems to me, from a layman's point of view, that the whole fabric of experimental investigation rests above all on a thorough knowledge of what is happening in our soils and why it happens. The whole art or science of farming starts with the soil and its management. But so long as we do not know for certain what is happening in these soils, how can we presume to advocate intelligently a method of soil management, or tillage, or cultivation? I have seen it stated in English agricultural publications that Sir John Russell had seriously questioned whether plowing as at present generally practised in farming, was the best way to manipulate the soil. Personally, I should like to see a large map of, say, two feet of average wheat soil, with every element and form of life, bacterial or otherwise, named and tagged and their proper functions and purposes clearly defined. I would like to see the exact chemical processes that are going on in the soil marked down clearly, showing how the minute soil populations are transforming the raw materials into food assimilable by the plants. In other words, I would like to know what is happening, and I put it to you, can we intelligently advocate a form of management of our soils that is the best form of management until we know these things?

There are many other instances of how the experimental investigator has been hampered through lack of the assistance of a thorough knowledge of fundamental principles, but the foregoing, I think, will show the point I am trying to make although I would like to suggest that there may be many other factors at present unknown and unappreciated that are having considerable effect on our practical experimental work.

It has become generally known, within recent years, that industry and commerce have thoroughly appreciated the great importance of scientific

fundamental research. To illustrate this I will merely quote you a paragraph from the November, 1926, issue of the Monthly Letter on United States Economic Conditions sent out by the National City Bank of New York, which is considered to be one of the best resumé's of conditions on this Continent:

"A fundamental fact is that the progress of industry never was so rapid as in the present, for the range of scientific research never was so great. All of the great industries have trained staffs studying how their processes may be improved and costs of production lowered. Every scientific discovery opens up a new field of knowledge of limitless possibilities in the industries. And the industries are changing with a rapidity unequalled in the past, thus lightening the burdens of human labour and multiplying the products."

I do seriously submit to you, gentlemen, that the business of agriculture in Canada is woefully lagging behind the business of industry as far as scientific fundamental research is concerned.

It is a curious fact that the science of medicine seems to have no difficulty in securing all the funds it requires for fundamental research. Perhaps this is due to the fact that experiments cannot be made upon human beings without the fear of killing them, and the medical world is forced to seek the aid of the biological chemist.

Enormous amounts of money are spent by Governments, by endowed institutions and by private individuals on scientific medical research. I venture to say that if sufficient funds, and men, and time, were available for similar research into agricultural principles, the experimental investigator would be so assisted in his work that he would develop much greater production of food stuffs per unit, both of soil and of man labour. Essential health foods such as bread, butter, eggs and meat would become so cheapened that instead of disease being prevalent and having to be cured by medical science, much less disease would be found in the human race because of the ability in the mass of people to secure within their means all the essential and healthy foodstuffs they require.

Consider the effect all this would have on immigration, which seems to be such a live problem in Canada today. The United States employs policemen to keep out of that country the large numbers of immigrants desiring to enter, whereas Canada employs honeytongued agents, whose business it is to persuade people to come to Canada. What is the reason for these two opposite situations? It is simply that the word has gone forth from industrial workers in the United States that good money can be earned there.

In this country of Canada, I do not think any decided voice has gone forth from Agriculture, which is the main business in Canada, that good money can be earned. But I firmly believe and always have believed that we have all the raw material and conditions for the development of a good money-making proposition out of agriculture if we could only understand a little more about it. Returns of six per cent net profits are assumed to

be fairly good. Therefore, it is fair to assume that an increase of only six per cent in the yields of all our farm products would almost double the present *net* profits. An increase of only three per cent would go a long way towards making the profits fifty per cent greater. My own several years of experience with farmers and my study of farm problems lead me to believe that if the net profits on the farms of Canada were only fifty per cent more than they are, or, in other words, if yields could be increased by three or four per cent, the immigration problem of this country would be solved. Agriculture then would become an industry sufficiently profitable to induce people who are already engaged in it to invite their friends and relatives to come out. After all, prosperous and satisfied farmers are the very best immigration agents for the business of agriculture.

It does not require much stretch of imagination, when we review the progress that has been made by the experimental investigator in the past, to believe that if money were available for proper fundamental research increased returns of more than three or four per cent would soon result. This brings us to another factor. Admitting the tremendous importance of small percentages of increases in the yield of our farm products, it would seem that the great difficulty today with our present method of experimental work is to be able, with certainty, to appreciate these small differences and recognize them when they do occur. I think I shall not be seriously contradicted if I make the statement that even with all the precautions which we are capable of taking, with all our mathematical applications for estimating probable errors, with all the elaborate and expensive tests of soil plots that we can make, so that we can neutralize the errors due to soil heterogeneity, such an increase in the yield of a crop as three or four per cent cannot today be recognized with certainty. If this statement is true, agriculture in Canada may be losing untold sums through the delay in making superior varieties or strains available to the farmer. But certainly a greater knowledge of what is happening biologically to soils, plants, and the processes of animal production must help to give the experimental investigator such control over his methods that he may be able to recognize these three or four per cent increases that, as I have pointed out, mean so much to the business of agriculture.

The great drawback of deductions from fit and try, or trial and error, experiments is that at best one can only say that these results were obtained at such and such a place, at such and such a time, and under such and such conditions. But if these experiments could be based on definitely known fundamental principles, then they would have a much better chance of being of much wider application, both in geography and time.

I would like to illustrate this by showing how this works out even in the art of warfare. Each army during the late war evolved certain methods of procedure against the enemy that were sometimes good at a particular place, and at a particular time, and against a particular kind of enemy. But it was rather striking to an observing person that there seemed to be no real fundamental principles involved in this military work until the

military scientist, Foch, took command. Now, Foch had always been characterized as a dreamer and a thinker, as a laboratory soldier, so to speak. He spent most of his life in the study of military history, trying to evolve principles rather than temporary methods.

As far as I was able to appreciate during the war, Foch put into successful effect the first real fundamental military principle that was used on a large scale, and because this principle was fundamental it was applicable by all armies at all times and on all parts of the front. The principle was simply this: that an army is in the least efficient condition to defend itself when all its energies and thoughts are involved in the process of attacking. In military art, the processes of attacking and defending are two entirely different things. Foch had very little more to do than to enunciate this mere principle and to indicate that the real time to attack an enemy was not when he was either passive or on the defence but after one had skillfully lured him on to an attack. There is no question that it was this fundamental principle that ended the war in favor of the Allies.

The point that I am trying to make is not that we have been doing too much experimental investigation. Far from this. Experimental work has been the means of advancing agriculture in Canada to the place that it holds today. Indeed I repeat, that no person can help having the utmost appreciation and respect for the splendid work already accomplished by existing institutions and by existing methods. But the truth, as I see it, is that this experimental investigation work has been greatly hampered and handicapped through lack of a better knowledge of biological fundamental truths. Perhaps, indeed, some of our experimental work has gone as far as it can go efficiently until some of these truths are available. I suggest, therefore, that it is you people, engaged in the business of experimentation, who should most loudly insist upon financial assistance for fundamental research work. I find, the world over, that there is a hesitancy on the part of Governments to allocate funds for pure research work, and I think it is because public funds must mainly pass through the hands of Governments who are agents of the tax-paying people, and it seems to be inherent in human nature to resist the payment of taxes. So these Governments cannot help putting into practice the never-ending and insistent demands for economy made upon them by the tax payer. They are therefore loath to allocate funds for any work unless that work can produce more or less immediate results.

I think that this pernicious influence is beginning to be felt even with the experimental investigator himself, inasmuch as we are hearing a voice, here and there, demanding that Experimental Farms, for instance, should be made to pay. And we find our Departments of Agriculture acceding to some extent to this popular outcry by trying to oblige experimental institutions to give practical services to farmers that farmers are perfectly capable of doing themselves.

Personally, I think this is all wrong. The proper business of an experimental farm or any other institution engaged in this work is to

experiment, wholly and solely, to find out new methods and better ways of increasing yields and quality and net profits in the business of farming.

If it should ever be decided that it is urgent for more research work, very much more research work, to be done, I would suggest that the avenue of private annual subscription be explored. I believe that in every human breast is an inherent desire to be affiliated with some worth while piece of work going forward for humanity. This is exemplified in the matter of religion, and in the success of the various Service Clubs throughout Canada. I believe that if a Society, for instance, that might be called the Canadian Society for Scientific Agricultural Research, were formed, and the general public invited to become members, with no set annual fees but a subscription from one dollar a year up, tens of thousands of dollars would be obtained annually from each Province for this work.

I have found that it is fairly easy to obtain money from people for a worthwhile object, provided two principles are observed: one is that the person asking for the money gets none of it for himself and the other is that only a moderate amount be asked from each person. The final large total donation is obtained by asking a great number of people. If there is in this country any person of means and leisure who wishes to devote some time to a very worthy cause, I know of nothing that would so help agriculture and the whole of Canada, than for such a person to interest himself in a scheme of this kind and obtain these funds for scientific fundamental research work.

From the Dominion Bureau of Statistics I find that the export of Canadian agricultural products in the year 1926 was, in round numbers, seven hundred and ninety-six million dollars. I presume that, broadly speaking, at least one-fifth of this amount would represent the value of agricultural products consumed in Canada. One would probably, therefore, be not far wrong in stating that the annual value of agricultural products in Canada is around one thousand million dollars. I am sure if this were a private business enterprise, that the allocation of one-tenth of one per cent of this amount, or, say, the sum of ten million dollars annually, would not be felt to be an exorbitant sum to pay for scientific research into this business of agriculture. But from the results that I have seen obtained with, comparatively speaking, insignificant sums of money, I am sure that even one-tenth of this amount, one million dollars a year, devoted to pure fundamental research, would be one of the best investments this Dominion of Canada could ever make.

It should, however, be thoroughly realized that fundamental research work cannot be hurried. No time limit can be set for the obtaining of results and the proper, quiet environment, free from all vexatious disturbances, must be afforded the people engaged in this patient and meticulous work, if proper results are to be expected.

FENN, ALBERTA.

## LES SOLS ET LES HOMMES\*

JACOB G. LIPMAN

Les sept mille années de la période historique n'apparaissent que comme un moment en comparaison avec le passé de la terre. Ils sont les derniers chapitres d'une longue histoire dans le cours de laquelle des continents surgirent des océans pour disparaître et reparaître encore. Dans le cours de cette histoire, apparurent de longues périodes d'aridité et de glaciation, d'atmosphère claire et douce, de froid rigoureux et mordant. Des milliards d'années de topographie changeante, de regroupement des continents, et de mers intérieures disparaissantes ont laissé leur impression sur la croûte terrestre. Une succession presque infinie de communautés végétales et animales apparurent et disparurent avant que l'homme eut commencé à ouvrir son chemin à travers l'obscurité. L'homme n'est qu'un nouveau venu dans le développement progressif de la création, un nouveau venu aux yeux de l'astronome, du géologue et du biologiste. Mais quand on le juge d'après les normes de l'anthropologie, de l'ethnologie, de la philologie, de l'archéologie et de la tradition humaine, il est le descendant d'un passé lointain et disparu. Il a vécu dans des milieux fort variés, il a senti beaucoup et a souffert beaucoup plus encore. Les terrains élevés, les plaines alluviales, les forêts denses et les vastes marais forment partie de son expérience subconsciente. De toutes ces impressions, il a retenu quelque chose qui reste fixé dans son esprit comme l'écho de tant de milieux, d'espace et de temps infinis. En fait, il a accompli l'impossible dans sa marche ascendante; comme a dit Goethe:—"Nur allein der Mensch vermag des Unmögliche."

Mais, quelque soit sa tentation de discuter le passé de l'homme, l'étudiant du sol doit laisser cela au philosophe et au poète; sa tâche est plutôt d'établir les relations entre climats, sols, plantes, animaux et hommes. C'est une fort vaste entreprise. En fait, la plupart des étudiants du sol se contentent de considérer le sol en lui-même, et seulement, en général, un seul groupe de problèmes. La science du sol doit bâtir une fondation assez vaste et solide pour supporter l'étude des ressources en aliments de la plante et de leur mobilisation, des interrelations entre le sol et les plantes, et des caractères et particularités du sol qui se reflètent dans la constitution des plantes et des animaux.

Les légendes et folk lores parlent souvent de la Mère Terre et de sa bonté. Pour jouir de cette bonté, ses enfants enlèvent au sol une partie de sa fertilité. Cet enlèvement ne peut pas continuer sans qu'un désastre final affecte le sol et les hommes qui en dépendent. On ne peut pas oublier la dénonciation passionnée de Liebig pour ce qu'il appela l'exploitation du sol, ni son appel pour la conservation du sol. Il nous dit:—"Les égouts de l'immense métropole du monde antique ont absorbé, dans le cours des siècles, la prospérité du paysan romain; quand les champs de ce dernier ne purent plus nourrir sa population, ces mêmes égouts dévorèrent la richesse

\*Rapport d'un travail présenté au congrès international de la science des sols, tenu à Washington, D.C., Juin, 1927.

de la Sicile, de la Sardaigne, et les terrains fertiles des côtes d'Afrique."\*. Prothero donne une image tout aussi sombre.\*\* Décrivant l'agriculture du Moyen-Age en Angleterre, il dit "Peu de facteurs pouvaient diminuer, pour les hommes ou les animaux, les horreurs de la famine hivernale. Rien n'est plus caractéristique de l'enfance de l'agriculture que la violence de ses changements. Sur les sols improprement fumés et sur lesquels ni les navets des champs, ni les trèfles ne furent connus pendant plusieurs siècles, il n'y a d'autre alternative que l'épuisement, dû à la culture continue, et le repos par la jachère."

Ces citations indiquent que la stabilité de la société humaine est affectée d'une façon vitale par les disponibilités en sels solubles, dans les sols de surface. L'origine géologique du sol détermine les ressources potentielles en sels solubles. Les facteurs climatiques, en particulier la pluie et la température, déterminent la rapidité de destruction de la roche, l'enlèvement des sels solubles, l'accumulation et la décomposition des matières organiques. Les activités humaines peuvent avoir affecté ou non la balance des forces naturelles. Le déboisement, le labourage des prairies, le drainage et l'irrigation, la culture du sol superficiel par les instruments agricoles, l'enlèvement du sol des produits animaux et végétaux, racontent l'histoire d'un façon claire.

Les effets désastreux de l'érosion sont bien connus de tous les étudiants du sol. Leur signification dramatique traduite par la destruction plus ou moins permanente de vastes régions de sols agricoles et forestiers n'est pas si bien appréciée par le public. Le lavage des sels solubles dans les sols humides non protégés par la végétation, et le drainage d'éléments nutritifs correspondant à la vente des récoltes et du bétail, doivent être suivis d'une stagnation économique et sociale. Dans les régions arides bien pourvues d'eau d'irrigation, l'accumulation des sels alcalins peut provoquer l'abandon de sols auparavant fertiles. La diminution des rendements peut être attribuée à un ou plusieurs facteurs. Parmi eux, on peut mentionner : la détérioration de la texture et de la structure, l'accumulation d'acidité, la perte de matière organique et de constituants minéraux des plantes, la concentration des substances toxiques dans la surface du sol, et le ralentissement des activités microbiennes.

Quelque simples que soient ces faits, ils attendent toujours une étude systématique de leur portée en termes de progrès humain—politique, social et économique. Nous devons à Hilgard d'avoir montré avec force et clarté que, au fur et à mesure que les sociétés humaines apparurent et passèrent, que les civilisations se suivirent, l'homme trouva les régions humides moins satisfaisantes que les régions arides pour assurer la stabilité et la permanence à la société organisée. Il conclut : "Dans les régions humides, comme on le sait, ce n'est que dans peu de cas que la culture peut-être continuée avec profit pendant plusieurs années, sans fumure. Mais pour être rationnelle et couronnée de succès dans les régions humides, l'agriculture doit être quelque peu retardée, et les tribus germaniques, comme les Indiens de l'Amérique du Nord, semblent avoir souvent changé leurs terrains de culture au cours de leurs migrations. Les habitants des régions arides ne ressentirent pas ce

\* Letters on Modern Agriculture, London, 1859, p. 229.

\*\*English Farming Past and Present, London, 1917, p. 33.

besoin pendant de longs siècles; la fertilité naturelle de leurs sols et les effets fertilisants de l'eau d'irrigation apportent de loin les éléments nutritifs, les délivrent du besoin de la fumure continue; dans les régions humides, la fertilité du sol est entraînée dans les eaux de drainage par les cours d'eau et les rivières, causant un appauvrissement périodique qui doit être corrigé par des moyens artificiels et coûteux. Les régions arides, en conséquence, se prêtèrent à l'établissement des sociétés complexes à culture élevée, dont on trouve maintenant les vestiges dans ce qu'on appelle les déserts, dont les sables ne demandent en général que les effets vivifiants de l'eau pour se transformer en champs fertiles et en jardins.

Mais, bien qu'il soit vrai que les anciennes sociétés trouvèrent dans les régions arides une plus grande permanence; bien qu'elles reconnurent les qualités plus durables des sols arides, elles développèrent quand même des méthodes empiriques de traitement du sol qui sont également applicables aux sols arides et humides. C'est maintenant la tâche des sciences biologiques et chimiques de donner une direction intelligente aux pratiques agricoles anciennes et modernes. Ces sciences ont ouvert de vastes possibilités de production. Elles ont montré comment on peut assurer aux sols humides une longue vie, sinon l'immortalité. Nous pouvons mesurer maintenant avec quelque degré d'exactitude les relations qualitatives et quantitatives des sols, plantes et animaux. Nous connaissons les sources de matières premières pour corriger les imperfections des sols et augmenter leur pouvoir producteur. En fait, nous avons développé une conception nouvelle de ce qu'on appelle communément de la plante, et de son emploi et conservation. Il y a de nombreuses années que Liebig paraphrasa comme suit une déclaration d'Albrecht Block: "Un fermier peut vendre et aliéner d'une façon permanente toute cette portion des produits de sa ferme qui a été fournie par l'atmosphère; un champ dont quelque chose a été enlevé d'une façon permanente ne peut pas augmenter ou même maintenir son pouvoir producteur."<sup>†</sup> La vue la plus moderne fut récemment exprimée par William J. Hale comme suit: "Quand nous contemplons la science de l'agriculture, nous sommes forcés de définir l'agriculteur comme un fabricant de produits chimiques organiques."<sup>‡</sup>

Le fermier doit donc avoir ses matières premières. Il les trouve dans le sol et dans l'air. De plus, il doit connaître les réserves potentielles de son champ quand les réserves de matières premières du sol sont supplémentées par des aliments de la plante venant de l'extérieur ou, peut être, quand la précipitation normale est augmentée par l'eau d'irrigation. Comme fabricant, il doit étudier l'économie de la production animale et végétale, les variations de son inventaire d'aliments de la plante, la consommation de luxe et la qualité des produits sous l'influence de la composition et du traitement du sol. Comme fabricant, il doit reconnaître que lui et ses confrères ont une communauté d'intérêts qui dépassent les frontières naturelles et politiques.

La production d'aliments pour l'homme et les animaux ne représente pas toute la responsabilité de ceux qui travaillent le sol. Naturellement, ils travaillent à transformer certaines substances chimiques simples en matières organiques complexes. Mais ils travaillent aussi à créer quelque

<sup>†</sup> Letters on Modern Agriculture, London, 1859, p. 175.

<sup>‡</sup> The Dearborn Independent, October 2, 1926.

chose de moins pondérable, de grande valeur si on le mesure en termes de compréhension humaine. On sait par exemple que les sols, plantes et animaux représentent une accumulation de carbone et d'azote qui, à un moment ou à l'autre, ont fait part de l'atmosphère. Le carbone et l'azote des sols sont présents sous formes de composés de différents âges. En fait, une partie de la matière organique du sous-sol est d'origine fort ancienne. Le carbone et l'azote de la végétation sont trouvés à la fois dans les plantes annuelles les plus délicates et dans les bois rouges vieux de plusieurs siècles. Le carbone et l'azote des animaux vivants représentent des transmutations relativement récentes de matériaux de la plante. Mais les résidus des flores et faunes anciennes contiennent quelque chose qui fut obtenu de l'atmosphère il y a fort longtemps. Nous en sommes convaincus quand nous examinons la série entière des matériaux carbonés—tourbe, lignite, charbon tendre, anthracite, jusqu'aux matériaux graphitiques.

Considérons rapidement, quelques unes de nos sources importantes de carbone dans le but d'obtenir une perspective plus claire des relations passées, présentes et futures entre les sols, les plantes et les animaux. Les données suivantes aideront peut être à refléter quelques unes des ces relations.

*Certaines Ressources de Carbone et d'Azote*

	Carbone Tons	Azote Tons
Atmosphère* .....	600,000,000,000	
Sols .....	400,000,000,000	40,000,000,000
Forêts .....	110,000,000,000	592,000,000
Tourbe .....	63,000,000,000	3,620,000,000
Charbon .....	6,360,000,000,000	40,000,000,000

Nous avons seulement besoin de noter que les sols et les plantes, anciens et modernes, sont un vaste réservoir potentiel de carbone et d'azote pour le développement des organismes vivants.

Comparons maintenant les données correspondant à la teneur en carbone, azote, phosphore et potassium des sols, forêts et de la population humaine et animale de la terre. Nous trouvons les valeurs suivantes.

*Quantités de Carbone d'Azote, de Phosphore et de Potassium des sols, Forêts et des Populations Animale et Humaine*

	C Tonnes	N Tonnes	P <sub>2</sub> O <sub>5</sub> Tonnes	K <sub>2</sub> O Tonnes
Sols .....	400,000,000,000	40,000,000,000	40,000,000,000	600,000,000,000
Forêts .....	110,000,000,000	592,000,000	93,000,000	260,000,000
Animaux .....	87,000,000	9,000,000	6,000,000	660,000
Population humaine .....	10,000,000	2,000,000	1,500,000	260,000

Bien que ces valeurs ne soient que très approximatives, elles suffisent à appeler notre attention non seulement sur certaines relations quantitatives, mais aussi sur le processus de fabrication des substances qui deviennent partie de la vie des générations humaines. Les matières premières, ainsi que le calcium, soufre et autres éléments ou composés simples, peuvent être utilisés intelligemment et effectivement, et, dans une telle utilisation, la science du sol peut servir de guide utile.

\*La quantité de carbone dans les roches sédimentaires est estimée être à peu près 30,000 fois aussi élevée que celle de l'atmosphère. Clarke, *The Data of Geochemistry*, 4th ed., p. 48.

Il existe une relation plus ou moins définie entre la constitution physique et mentale de l'homme et la nature du sol. Des études systématiques manquent encore concernant le rôle que les sols ont joué dans le passé et jouent maintenant en déterminant les particularités des races et des individus. Nous savons que la composition des plantes varie beaucoup. Les sols qui fournissent d'abondantes quantités d'azote et de substances minérales facilement assimilables produisent généralement des plantes contenant une proportion relativement grande de ces constituants. De plus, la teneur en azote et en cendres des aliments a un effet direct sur la croissance et le développement des animaux et des hommes. En conséquence, il n'est pas impropre de déclarer que la nourriture, en sa quantité et qualité, s'exprime en termes de quantité et qualité humaine. L'abondance et la quantité de la nourriture se sont fait sentir au cours de l'histoire. Elles ont influencé la politique et la législation rurale des races et des nations. C'est pour quoi l'étudiant du sol est souvent tenté d'analyser, sinon de déterminer, l'importance des sols comme facteur de l'histoire humaine. Le moment viendra peut être quand notre connaissance de ce facteur sera assez complète et précise pour nous donner une perspective propre.

Dans le passé lointain, les hommes des différentes régions vivaient comparativement isolés. Il existait un interchange limité d'idées, et encore plus limité de produits. Le fermier essayait de se suffire à lui-même, ainsi que les différentes nations. La nourriture d'une région était presque exclusivement d'origine locale. En conséquence, avant le commencement du 19<sup>ème</sup> siècle, la circulation de produits alimentaires de la ferme vers la ville et de pays à pays était plus limitée. Dans une certaine mesure, les villes elles-mêmes étaient des villages agrandis, et une proportion appréciable de la nourriture qu'on y consommait était produite dans les jardins de la ville ou des environs immédiats. Dans de telles conditions, les différences de composition du sol se reflétaient d'une façon plus marquée dans l'alimentation des différentes communautés. Des distinctions si marquées se sentent encore sur une grande partie du globe. Il est vrai, en même temps, que nos grandes cités modernes reçoivent couramment leur nourriture de nombreux endroits, quelques uns situés à de grandes distances. Comme exemple, on peut noter que la ville de New York reçoit ses fruits de la Côte du Pacifique, son beurre et ses produits laitiers du Centre-Ouest, ses légumes et ses volailles de la Côte Atlantique. New York reçoit sa nourriture non seulement de presque toutes les provinces agrologiques des Etats-Unis, mais aussi de l'Europe, l'Asie, l'Australie, l'Afrique et l'Amerique du Sud. Pour cette raison, les habitants de New York, ainsi que ceux d'autres grandes cités, ont utilisé une nourriture plus variée, contenant à différents degrés: protéines, hydrates de carbone, graisses, vitamines et éléments minéraux. C'est le rôle de l'étudiant du sol de se familiariser avec les importations et exportations de produits agricoles pour autant qu'elles jouent un rôle dans la fertilité du sol des différentes régions. La science du sol a la responsabilité de maintenir des contacts avec les progrès de l'industrie et des transports, puisque ceux-ci jouent un rôle dans le mouvement des produits agricoles, et conséquemment, ont une influence assez proche sur les systèmes de culture et les pratiques culturelles de tous les pays. Il ne serait pas trop de dire que les mouvements économiques, politiques et sociaux sont basés, dans une certaine mesure, sur les ressources

des sols. Pour cette raison, la science du sol peut être employée effectivement pour donner la direction convenable à la solution de ces importants problèmes.

D'une façon plus immédiate, la science du sol a des responsabilités définies en indiquant des méthodes rationnelles et effectives d'utilisation du sol. Comme étudiants du sol, nous reconnaissons la nécessité de méthodes standard pour l'étude de la classification et de la cartographie des sols. A l'honneur des prédécesseurs de ce Congrès, il faut dire que beaucoup a déjà été accompli par les conférences internationales du sol. On peut espérer que la tâche sera terminée dans un avenir prochain. Quand ce temps viendra, les économistes ainsi que les propriétaires fonciers connaîtront d'une façon plus concrète les potentialités des différentes régions agrologiques, et les méthodes propres à assurer une production économique maximum. En établissant des méthodes standard de classification et d'étude du sol, nous hâterons le développement d'un programme national d'utilisation du sol dans tous les pays. Nous assurerons alors l'intensification de la production, et l'alimentation de la population croissante du monde. C'est le devoir de la science du sol d'établir d'une façon plus claire la relation entre les récoltes et les sols, de façon à assurer une meilleure utilisation des aliments de la plante, de l'énergie solaire et du travail humain. La science du sol devrait enseigner à l'agriculteur comment modifier pour le mieux la qualité de l'aliment par le traitement du sol. Il devrait envisager un programme de recherche et d'éducation beaucoup plus vaste et perspicace de façon qu'il puisse servir d'une manière toujours plus large les besoins de la société humaine qui, d'année en année devient plus complexe dans son organisation et plus exigeante dans sa demande pour les produits du sol, essentiels au maintien des valeurs morales et spirituelles qui sont la mesure finale des activités humaines.

Nous arrivons ainsi à un problème mondial d'aliments de la plante, de l'animal et de l'homme. Comme étudiants des sols et de leurs ressources, nous devons penser non seulement à l'aliment de la plante, mais à sa mobilisation. Nous devons considérer la solution du sol non pas comme seule dans ses relations locales, mais comme une partie de la grande masse d'eau fraîche se mouvant vers la mer. Nous devons considérer les kilomètres cubes de sédiments déposés à l'embouchure des rivières comme une taxe sur le sol et ceux qui le cultivent. Nous devons comprendre dans nos études la circulation du carbone, de l'hydrogène, de l'azote et du soufre comme affectée par la combustion et la fermentation. Nous devons penser, finalement aux plantes et animaux anciens ainsi que vivants comme possesseurs de quelque chose qui, dans l'atelier de la création, doit être employé toujours et toujours de nouveau. Nous sommes les conseillers techniques des nations qui sont les gardiennes des précieuses matières premières. Celles-ci doivent être employées sagement et conservées efficacement, de façon que l'humanité puisse voyager sans trop de souffrance et de misère sur la route de sa destinée.

## CONCERNING THE C. S. T. A.

Our appeal for financial assistance for publication purposes, addressed to the Federal and Provincial Departments of Agriculture, the Agricultural Colleges and the National Research Council, is meeting with quite satisfactory success. In several of the Provinces no final decision has yet been made, and the only two Provincial Departments of Agriculture which refused to give any assistance did so because of unusual financial circumstances which necessitated the curtailment of expenditure.

A grant of \$500.00 by the National Research Council is to be considered at a Council meeting in Ottawa on October 11th.

Definite assistance has been given by the Federal Department of Agriculture and the Provincial Departments of Agriculture in British Columbia, Ontario, Quebec and Nova Scotia.

The Universities of Saskatchewan and Manitoba, the Ontario Agricultural College and Macdonald College have also agreed to contribute the amount requested. Final decision has not yet been made by the Universities of Alberta and British Columbia.

By the end of October we hope to be able to publish a complete list of those sources from which grants have either been received or are to be expected. In the meantime, the journal is maintaining the standard set by the September issue.

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The General Secretary attended a meeting of the Niagara Peninsula local at Grimsby on September 10th. This local is arranging to hold a large meeting, also at Grimsby, on Saturday, October 8th, to which all the members in Toronto and Western Ontario are being invited. It is hoped that Mr. Philippe Roy, the President of the Society, will be able to attend. Any member of the Society, or anyone contemplating membership, is invited to the Village Inn, Grimsby, for a banquet at 6 p.m. on October 8th. We are informed on good authority that the members of the Niagara Peninsula local are giving the banquet to the visiting members.

The Macdonald College branch is planning a one day meeting at the College on November 25th, with a series of discussions in the afternoon, a dinner at 7 p.m. and a social evening. The principal speaker is to be Professor J. E. Boyle, Head of the Department of Agricultural Economics at Cornell University.

The Eastern Ontario local is opening its winter activities with a dance at the Hollywood Studio, Ottawa, on October 27th. This is to be followed by a luncheon on November 24th and regular meetings, social or otherwise, during the winter.

## NOTES AND NEWS

Several members of the staff of the Dominion Department of Agriculture are at present in England or on the Continent. Some of them will attend the Imperial Research Congress in London, others are attending special meetings in Europe or investigating market conditions. Those who are abroad now include Dr. J. H. Grisdale, Deputy Minister of Agriculture; Mr. E. S. Archibald, Director of Dominion Experimental Farms; Mr. W. T. Macoun, Dominion Horticulturist and Dr. J. M. Swaine, Associate Dominion Entomologist. All are expected back in Canada by the end of November. Mr. George E. McIntosh, Dominion Fruit Commissioner, has been invited to England by the Empire Marketing Board and will sail about the middle of October.

K. W. Neathy (Saskatchewan '24) is taking post graduate work at the University of Minnesota. His address is 1264 Knapp Place, St. Paul, Minn.

A. Savage (McGill '11) sailed from Montreal on September 16th on the S.S. "Montrose". F. B. Hutt (Toronto '23) sailed the same day on the S.S. "Andania." Dr. Savage is going to spend about nine months at the Royal Veterinary College, Edinburgh, and Mr. Hutt will be in the Animal Breeding Research Department at the University of Edinburgh for at least a year.

E. B. Fraser (British Columbia '25) is taking post graduate work in animal nutrition at the Iowa State College. His address is 315 Lynn Avenue, Ames, Iowa.

E. T. Chesley (Toronto '22) has accepted a position on the Editorial staff of the *Ontario Farmer*, Richmond and Sheppard Streets, Toronto. He has been Assistant Editor for the Division of Extension and Publicity, Central Experimental Farm, Ottawa, since 1923.

We learn that W. H. Perron (McGill '23) has been awarded a scholarship of \$1,200 and is leaving for special studies abroad. Particulars are not available.

W. A. DeLong (Toronto '20) advises us that his address in St. Paul, Minn. is 2089 Carter Avenue. He is in the Division of Agricultural Biochemistry.

R. R. Fleming (Toronto '17) has been transferred as Agricultural Representative, from Milton, Ontario to Welland, Ontario.

C. Perrault (McGill '26) is Assistant Plant Pathologist at the Dominion Laboratory, St. Catharines, Ont.

C. M. Meek (Toronto '22) has resigned from the Agricultural Representative service in Ontario. He is now with the Municipal Bankers Company, 34 King Street East, Toronto. He has been succeeded at Carp, Ontario, by J. J. E. McCague (Toronto '21).

A. E. Richards (British Columbia '23) Supervisor of Dominion Illustration Stations for British Columbia, has been transferred from the Experimental Station at Summerland to the Experimental Farm, Agassiz, B.C.

A. T. Elders (Manitoba '24) has been appointed Assistant Agrostologist at the Dominion Experimental Farm, Brandon, Man.

E. A. Atwell (McGill '23) has been appointed Forest Products Assistant in the Forest Products Laboratories, Dominion Department of the Interior. His address is Y.M.C.A., Ottawa.

H. J. Siemens (Manitoba '25) and W. G. McGregor (Toronto '24) are taking post graduate work in Agronomy at the University of Minnesota. Both can be reached at the Division of Agronomy, University Farm, St. Paul, Minn.

#### AT THE CENTRAL OFFICE

About the middle of September, the General Secretary mailed the C.S.T.A. Handbook to every member of the Society and is using additional copies as the basis for a membership campaign. This campaign is being directed chiefly towards the graduates of 1924, 1925, 1926 and 1927, as it is considered that most of the older graduates who intend to join the Society have already done so.

It is too early to report results. One or two applications have already been received and it is expected that a considerable number will reach the central office during October. In the meantime members can assist in the campaign by placing an application form (last page of Handbook) in the hands of an eligible member. This is the surest way of securing results.

Immediate steps are being taken to re-organize the Bureau of Records and Employment. Those members whose records are not available at the central office will again be asked to co-operate and it is hoped that by the end of the calendar year there will be a complete record of the biographies, academic training and professional experience of every member.

The preparation of these records will permit the arrangement of the membership body into various groups, depending upon the branch or branches of agriculture in which each member is engaged, or in which he is chiefly interested. There appears to be a pronounced tendency towards group organization within the Society and the Quebec Convention in 1928 will be organized on the group system. If the allocation of members into groups can be completed during the next few months, the organization of these groups can be quickly completed and their permanence assured.

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The 1928 List of Members will be published as usual about the middle of March. Several members have suggested that the C.S.T.A. "Who's Who", the first edition of which was published at \$2.00 per copy in 1924,

should be published again in 1929. If there is a general demand for a second edition of the "Who's Who", it will probably be possible to publish it at a slightly lower cost. The first edition contained 700 biographies, and a second edition would contain at least 1,000. If every member purchased a copy at \$1.00, the deficit would not be serious.

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The General Secretary will attend the Grimsby meeting on October 8th, at which it is hoped that interest will be stimulated in a new local branch in Western Ontario, with headquarters at Chatham or London. The present Western Ontario local would then become the Toronto local.

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Mr. L. P. Roy, President of the Society, has asked the General Secretary to be in Quebec on October 12th to meet a special committee and to discuss plans for the 1928 Convention. This will be the first meeting of several which are to be held during the coming winter. The members of all local branches in the Province of Quebec will do everything possible to arrange a social and business programme which will be attractive and profitable. The full support of the Quebec Department of Agriculture has already been assured. Motor trips to the Agricultural School at Ste. Anne de la Pocatière, the historic Montmorency Falls (Kent House), and other points of interest are being arranged. For the first time in the Society's history, the lecturers at the Convention will include at least one European in the person of Dr. Volkart of Zurich, Switzerland. Every member who can arrange to be in Quebec next June should do so. Definite dates will be fixed at the preliminary meeting on October 12th and announced in the next issue.

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The attention of members is again directed to the importance of using *Scientific Agriculture* as a medium for publication of original work. The next issue will include two articles submitted from the United States and while we are very pleased to receive manuscripts from Canadian graduates across the border, we naturally want our own workers in Canada to give at least equal support to the journal in its new form.

Manuscripts can be published within three months after their receipt. Proofs are always submitted to the author three weeks before the date of publication and 100 reprints, without covers, are furnished free if the author desires them. A reasonable number of illustrations will also be published, if they are received with the manuscript.

The financial problem involved in the changing of the magazine to the present size and quality appears to have been solved. If members will do their share by contributing suitable material, the journal will soon be established as one of the most useful and creditable publications of its kind.